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Bradley's Spleenwort.

Frontispiece.

FERNS

A MANUAL FOR THE NORTHEASTERN STATES

WITH ANALYTICAL KEYS BASED ON THE STALKS AND ON THE FRUCTIFICATION

With over Two Hundred Illustrations from Original Drawings and Photographs

BY

CAMPBELL E. WATERS

(*Ph.D., Johns Hopkins*)

NEW YORK

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PREFACE

COMPARATIVELY few amateur botanists pay any attention to the ferns, being content to pass them by with the remark that "they are very difficult to study." This is to a certain extent true, for it is not always easy to obtain specimens in the proper condition for identification by the ordinary keys, all of which are based on the fructification. During a large part of the year their study is impossible, except to one already somewhat familiar with the genera. For nearly ten years the author has been interested in the stalks of ferns, and in 1894 began to study them comparatively, and succeeded in working out an analytical key, based upon their characteristics, which included thirty-three species then known to occur near Baltimore. This was so favorably received by amateur botanists that it was thoroughly revised and enlarged in 1901. It seemed advisable to write a "popular" manual based on this key and illustrated by photographs of all the species. In using the key it is unnecessary to have the ferns in fruit, and even small plants of large species can be identified by means of it, which is an advantage over other analytical keys.

The illustrations are from original drawings and photographs. The latter speak for themselves, the series showing the typical fruit-dots of the genera being, it is believed, unique. The same is true of the pictures showing

the development of the sporelings, the walking-fern, and the bulbiferous bladder-fern. The chapter on Fern Photography gives a full account of the methods employed.

For fourteen years the author has kept in touch with many of the ferns "in the field," and with six or eight exceptions has specimens of every species and variety described. The book is not a mere compilation from others, but embraces the results of general observations or special studies, and suggestions for further investigation are made here and there. The following books have been consulted especially for descriptions of species, for information regarding their distribution, and for the definitions in the glossary: Gray's "Manual," Underwood's "Our Native Ferns," Mrs. Parsons' "How to Know the Ferns," Clute's "Our Ferns in their Haunts," Coulter's "Plants," Britton's "Manual," Eaton's "Ferns of North America," Giesenhagen's "Botanik," Warming's "Oekologische Pflanzengeographie," the "Fern Bulletin," and the "Botanical Gazette," as well as the check-lists of Gilbert and Maxon.

The book is intended to cover the same territory as Gray's "Manual." All the ferns in the Northeastern States are described and illustrated.

It may be thought that scientific terms have been used too freely (though not exclusively), but any one who wishes to go beyond this book will soon need to know the meaning of all we have used and many more. They are most easily learned a few at a time. The best excuse for using them is that they are more exact than ordinary language.

C. E. W.

Baltimore, May, 1903.

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FERNS

INTRODUCTION

"Nature made ferns for pure leaves to show what she could do in that line."—THOREAU.

AS we pass through the vegetable kingdom from the lowest to the highest plants we find a gradual increase in the complexity of their structure and their methods of reproduction. It is a far cry from the one-celled bacteria and algæ, that multiply by simply splitting in two, to the orchid, for instance, with its countless cells forming the various tissues each with a different part to play, and its complicated arrangements for producing its seeds. Yet between the two we find an endless variety of plants showing how Nature has by successive steps developed the higher plants from simpler types. Between the alga and the orchid we find the ferns which lie close to the boundary line which separates the flowering from the flowerless plants. Although classified with the latter because they have no flowers, they resemble the flowering plants in some respects. The mosses, which are next below them in the scale, have very simple leaves and stems, but in the ferns we find leaves quite as compli-

cated in structure as those of many flowering plants, and stems through which run woody fibers. As we shall see in the chapter on Reproduction, they still reproduce their kind by means of spores instead of seeds, in which respect they are inferior to the flowering plants. At the same time the structures concerned in this reproduction are of a higher type than we find in the mosses.

The appearance of the woody fibers was an important event in the development of the vegetable kingdom. They extend from the root-tips to the edges of the leaves, in which they form the "veins," and serve to strengthen the entire plant, as well as to conduct the sap to all parts of it. In the flowering plants these fibers, or "fibrovascular bundles," are scattered irregularly through the stems or arranged in concentric rings around the pith. In the ferns they are arranged somewhat differently, yet always with a certain symmetry, and in such a way as to stiffen the stems as much as possible. If we cut across a stem, the ends of the bundles are seen as dots or lines surrounded by soft tissue. (See illustrations in the key, page 68.) They are so placed as to overcome the strain on the front of the stem by resisting the bending-force of the weight of the leafy part. By crushing a stem carefully the bundles may be removed. They form long, elastic strings of considerable strength.

The number of bundles depends somewhat on the size of the stem. Many ferns have only one or two bundles, no matter how large the given specimen may be, but in other kinds the number may vary from three to nine,

according to the size. Of course, the higher up from the base the fewer the bundles, for the stems are thinner there and have less weight to support.

Ferns are classified, primarily, according to their fructification, and the number of fibrovascular bundles is of little scientific value in this respect, but when taken in connection with the ridges, grooves, and other peculiarities of the stems, the identification of the ferns described in this book becomes a comparatively simple matter. An analytical "key" has been worked out, in which the ferns are classified according to the number of these bundles in the stems. At the same time, for the benefit of those who might prefer to go about the study in the true scientific way, a key based on the fructification is also included. With these two, and with the aid of the illustrations, there should be little trouble in identifying any fern that may be met with in a woodland ramble.

The Distribution of Ferns.—Ferns are found in nearly all parts of the earth, from the arctic zone to the tropics. In the cold countries they are not very abundant, but the number of kinds, as well as of individuals, increases rapidly as the climate becomes warmer. In New England and the Middle States there have been found between sixty and sixty-five species. Contrast this number with the four hundred and sixty species said to be found on the island of Java. The great heat and moist atmosphere of tropical islands is especially favorable to the growth of ferns, and they are found not only on the ground and upon rocks, as with us, but even growing upon the topmost branches of

"The lady-fern . . . can be found in the lower parts of the woodland."
Page 4.

trees. In our latitude the largest and most beautiful ferns are found in swamps or in rich woodlands near streams. Let the swamp be drained or the trees felled, and in a single season the ferns show the ill effects of the change.

WHERE to Look for Ferns.—We may be quite sure of finding ferns in any woodland, especially if there is a stream running through it or if it is partly low and moist. The lady-fern and silvery spleenwort, the wood-ferns and crested shield-fern, the chain-ferns and Massachusetts fern, the royal, cinnamon, and interrupted ferns, the ternate and dissected grape-ferns, and many more can be found in the lower parts of the woodland. Where it is drier we should look for the New York fern, the Virginian grape-fern, and the beech-ferns, the oak-fern, and the Christmas fern. If the ground happens to be rocky, the marginal shield-fern and the maidenhair are apt to be abundant, while on the larger boulders is a covering of the polypody. With it we may find the maidenhair and ebony spleenworts and the walking-fern. Look along the edge of the wood where the stream starts across the meadow and we will find the outposts of the marsh shield-fern and the sensitive fern, whose hosts are out in the full sunlight, where they surround clumps of taller-growing royal and cinnamon ferns.

To find all these and the rarer ones that are with them

The New York Fern.

Page 6.

means many a day of tireless tramping and often fruitless search, but the hope of making a "find" is sufficient incentive, and the realization inspires us to renewed efforts. No one minds five miles of hot, dusty road if at the end of it is a cool woodland filled with the Massachusetts fern, the two chain-ferns, a new variety of the cinnamon-fern, and others of interest. No effort was too great when we were told just where to find the rare Bradley's spleenwort, and the reward was even greater than we had hoped, for with it was the mountain spleenwort which the other botanist overlooked. Who would not call the day well spent that brought to light "two miles of purple cliff-brake" and the first ostrich-ferns reported from Maryland? These are "red-letter days" to be dreamed of long afterward, and recalled with as much pleasure as many other achievements of life.

Not all localities are equally favored in the number of kinds of ferns found in them. Every botanist has friends who tell of the "woods near the house where there are about forty kinds of ferns," but he will not be misled by such statements. He knows there may be six or eight, but if he is wise, keeps silence. Some places are so "civilized" or otherwise uncongenial that few ferns are to be found, but in others the great diversity of conditions may cause them to be the home of many kinds. There is one little woodland, about two acres in extent, that we often visit, in which grow twelve species, while just across the road are two more. Within twelve miles of Baltimore we have collected forty-six species and varieties, and all but eight or

The Marginal Shield-ferns.

nine of these can be found within half that distance. No doubt there are even richer regions.

Genus, Species, and Variety.—What do we mean by the terms *genus, species,* and *variety*? A species is what we call, in ordinary speech, a "kind." The cinnamon-fern, the royal fern, and the Christmas fern are different kinds or species of ferns. Not all plants of the cinnamon-fern are alike, for they differ not only in size but in the shape and cutting of the leaves, or *fronds* as they are called by botanists. Still, we recognize that we are dealing with the same kind of fern; there are certain points of resemblance common to all forms of the cinnamon-fern. Whenever, then, we have a number of ferns with more essential points of resemblance than of difference we class them under the same species. The question as to what constitutes "essential points of resemblance" is not always easy to decide, and there is a wide difference of opinion among botanists regarding the limits of the different species. This book may be said to be on the conservative side, though no criticism is offered of those who prefer to increase the number of species.

Now suppose we find a number of different kinds or species of ferns that resemble one another in certain important points. These would be included under the same *genus.* The royal fern, the cinnamon-fern, and the interrupted fern are alike in having spore-cases of a peculiar type borne in essentially the same way on the fronds; and they have other features in common. They are plainly related to one another and are put in the same genus.

Chain-ferns and Cinnamon-fern.

Page 10.

Plants of the crested shield-fern are sometimes met with in which the *pinnæ*, or divisions of the fronds, are cut differently from the ordinary form, and which have other peculiarities, so that they might almost be taken for another species. But such variations are unimportant in comparison with the resemblances, and do not justify us in calling it another species, but simply a *variety*.

When the points of difference are even less important, and especially if it appears that the variation is caused by a difference in the surroundings or in some such way, the plant is not even called a variety of the species, but simply a *form*. If a plant of the sensitive fern is chopped down in early summer, it sends up new fronds that often present certain peculiarities, and seem to the uninitiated to belong to some other fern. But they clearly do not, for if uninjured the typical fronds found on most plants of the sensitive fern will appear the next season. It is merely a transitory "form" of that species.

Scientific Nomenclature.—Every kind of fern or other plant has a *generic* and a *specific* name, the two together serving to distinguish it from all other plants. The generic and specific names correspond, we may say, to a person's family and given names, respectively, and they are always used in the order given. The genus to which the cinnamon-fern and the two related species belong is called *Osmunda*. Each of the three is an *Osmunda*. To distinguish the cinnamon-fern from the other two we must also give its specific name, *cinnamomea*. To botanists it is *Osmunda cinnamomea*. The two together are fixed and may be

"The little woodland in which grow twelve species."

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applied to no other plant in the world. Of course, the generic name is given to the other two kinds, and any number of plants in other genera may have the specific name *cinnamomea*.

The names of varieties and forms are placed after the name of the species, usually with "var." or "f." between; thus, *Nephrodium cristatum* is the crested shield-fern. The variety is called *Nephrodium cristatum* var. *Clintonianum*. The peculiar form of the sensitive fern is *Onoclea sensibilis* f. *obtusilobata*.

Common Names.—From what has been said above, the advantage of knowing the scientific name will be evident when we remember that many plants have more than one common name, and the same common name may be applied to several different plants. Then, too, comparatively few ferns have common names that have grown up with them, and most of those in present use have an unnatural, artificial sound. Wall-rue and maidenhair, brake, and lady-fern are old names in the same class with buttercup and daisy. Walking-fern and cinnamon-fern are more modern, but thoroughly appropriate. It is unfortunate that we seem compelled to use "common" names which are not so at all, but simply translations of the scientific ones, as, for instance, "hairy lip-fern" and "Braun's holly-fern."

Forking Fronds.—The fern student will find many variations from the usual type in most of our ferns, especially as regards forking of the tips of the fronds and pinnæ. We have found cases of this kind in more than twenty-five of our species, and occasionally two perfect fronds on

one stalk. It is not known just why these peculiarities should occur, and they may have no especial significance,

Forked Fronds of the Christmas Fern.

although it has been suggested by L. M. Underwood that they may "involve the question of ancestry of existing ferns."

It is undoubtedly true that some species are found to fork much more frequently than others. The purple cliff-brake, the broad beech-fern, the walking-fern, the hart's-tongue, and some others are often found in this condition, while such a thing is rather unusual in the Christmas fern, ebony spleenwort, marsh shield-fern, and others. It does not appear how far heredity is responsible for this, but a plant that once produces forked fronds is apt to do so in succeeding years. At one end of a rock on which the walking-fern grows we are always sure of finding two or three forked fronds each year. It would be an interesting

The Ostrich-fern.

Page 15.

experiment to see whether the young plants from forked fronds were more apt to show the same tendency than those from unforked fronds on the same parent plant. This would require a series of careful observations lasting for several years. A similar experiment might be carried out with the spores from forked and unforked fronds of the same plant.

In some cases it would seem as if the environment were largely responsible for the abnormal development. Some years ago a colony of the broad beech-fern, in which practically every frond had much forked and folded pinnæ, was found in a sunny spot near a stream. In three or four years the neighboring alders had grown so as to shade the spot, and no abnormal fronds are found there now.

A forking or, rather, double frond of the pinnatifid spleenwort is shown in the illustration on page 131, and one of the fragrant fern on page 212.

Fossil Ferns.—The earliest fossil remains of ferns are found in rocks of the Devonian age, but they were most abundant during the Carboniferous age. At that time ferns of great size, as well as small ones, existed in enormous numbers, and their remains, together with related plants allied to our horsetails and ground-pines, form our coal deposits. In many instances very perfectly preserved specimens have been found, and a large number of species has been described. It is very doubtful, in spite of statements to the contrary, whether any of those ancient species have survived to the present time. In the more recent formations several modern genera are represented, however.

In a valley centuries ago,
Grew a little fern-leaf green and slender,
Veining delicate and fibers tender,
Waving when the wind crept down so low;
Rushes tall and moss and grass grew round it,
Playful sunbeams darted in and found it,
Drops of dew stole down by night and crowned it.
But no foot of man e'er came that way—
Earth was young and keeping holiday.

Monster fishes swam the silent main,
Stately forests waved their giant branches,
Mountains hurled their snowy avalanches,
Mammoth creatures stalked across the plain;
Nature reveled in grand mysteries;
But the little fern was not of these,
Did not number with the hills and trees,
Only grew, and waved its wild sweet way;
No one came to note it day by day.

Earth one time put on a frolic mood,
Heaved the rocks, and changed the mighty motion
Of the deep strong currents of the ocean;
Moved the plain and shook the haughty wood,
Crushed the little fern in soft moist clay,
Covered it and hid it safe away.
Oh, the long, long centuries since that day!
Oh, the changes! oh, life's bitter cost!
Since the useless little fern was lost.

Useless? Lost? There came a thoughtful man
Searching nature's secrets far and deep;
From a fissure in a rocky steep
He withdrew a stone o'er which there ran
Fairy pencilings, a quaint design,
Leafage, veining, fibers clear and fine,
And the fern's life lay in every line!
So, I think, God hides some souls away,
Sweetly to surprise us the Last Day!

M. B. Branch.

THE REPRODUCTION OF FERNS

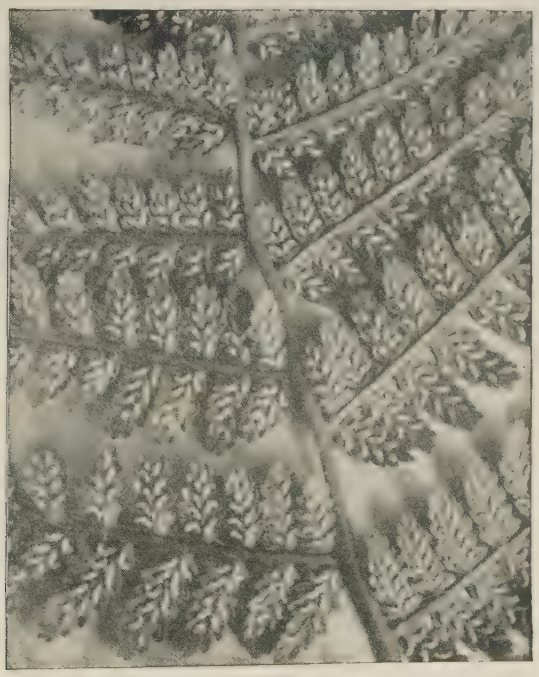
THE Flowerless Plants. — We are only too apt to think of the flowerless plants, or *Cryptogams*, as a comparatively unimportant collection of plants of little use and few in number—a few fungi and lichens, the ferns and ground-pines, and seaweeds. It comes as a surprise to learn that the flowerless plants are more numerous and exhibit greater diversity than the flowering plants. To illustrate, a recent text-book devotes 167 pages to the former and 109 to the latter. The popular opinion is excusable, for the majority of cryptogams are microscopic, or at least quite small and inconspicuous, so that they usually pass unnoticed.

Great as their differences may be, they are all alike in reproducing their kind, not by seeds, but by *spores*. A seed is a miniature plant, more or less complete and often provided with an extra supply of nourishment to give it a good start when it germinates. A spore, on the other hand, is a minute, usually round or oval, one-celled body. Small as the spores are, the way in which they are produced and their subsequent germination and development

are important points in the classification of the flowerless plants.

Modern research has done much to break down the old barriers between the two classes, and has shown that seeds are preceded by spores in the ovules and pollen-grains, but for practical purposes the old distinction holds good.

Fern-spores and Spore-cases.—If, in midsummer, we look on the under side of some of our common ferns, we will see certain brown spots that are often covered by thin, whitish membranes. These dots are known as fruit-dots,



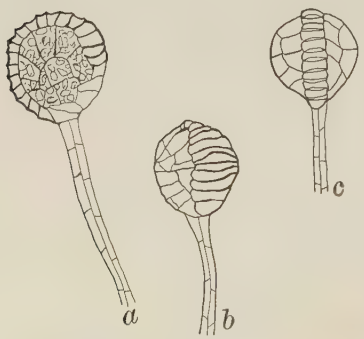
Sori of the Lady-fern (magnified)

or, in botanical parlance, *sori* (singular *sorus*). The protective membrane is known as the *indusium*, or shield.

The sori are, as the Greek word indicates, "heaps" of smaller bodies, the spore-cases, or *sporangia.* In the spore-cases are developed the spores which are set free when mature.

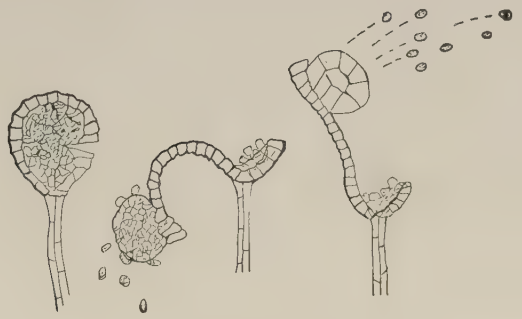
In a scientific classification the spore-cases and fruit-dots are of first importance. The families are based primarily on the spore-cases, and they are subdivided into tribes and genera according to the way in which the spore-cases are borne on the fronds.

The Families of Ferns.—Among the ferns described in this book there are representatives of five fern families. Most of them belong to the Polypodiaceæ, a family named after the genus to which the common polypody belongs. It is the largest of all the families, and its members, scattered over the earth, vary in size from tiny Woodsias and spleenworts growing on rocks to the graceful tree-ferns whose slender trunks, rising to the height of fifty feet or more, are crowned with a circle of fronds often fifteen feet in length. The accompanying drawing will give an idea of the character of the spore-cases. They are tiny, stalked capsules encircled incompletely by a jointed ring, called the *annulus.* At *a* is given a side view of a spore-case, showing the ring and the thin side walls through which the spores can be seen. At *c* the sporangium is seen from the back, while at *b* we have an



Sporangia of *Polypodiaceæ.*

oblique view showing where the sporangium splits open at maturity. When the spores are nearly ripe the drying of



Sporangia Discharging Spores.

the ring produces such a strain that it finally bursts the thin sides of the spore-case. This of itself would allow the spores to drop out, but nature has provided a better way. As the ring straightens it tears the spore-case in such a way that most of the spores are held at its free end in a kind of little basket formed by the walls. The ring bends far backwards, almost in a complete circle; then it straightens with a jerk and the spores are sent flying. The whole operation may be watched under the microscope by scraping off some of the brown, unopened sporangia upon a glass slide and letting a drop or two of strong alcohol or glycerin run in under the cover-glass. The moisture is removed from the ring by this treatment, and the spores are soon discharged. With a good pocket-lens one can watch the phenomenon, though less satisfactorily. In this case it is a good plan to keep a frond, on which the spore-cases are nearly ready to open, for a day or two in a tin box with some moist blotting-paper. When removed from this

saturated atmosphere the sporangia soon dry out and a rapid bombardment takes place. In pressing ferns we have often noticed, when a heavily fruited frond is removed from the damp driers, a distinct "effervescing" noise caused by the bursting of hundreds of sporangia simultaneously.

The sensitiveness of the spore-cases to moisture is a great advantage to the ferns, for they depend on the wind to scatter the spores. In rainy weather, when they might be beaten down to the ground at once, the spores are kept safely shut in, but when the drying winds come they are soon sent on their way, and may be carried great distances. As an illustration of this, we were long familiar with an abandoned iron-furnace and a near-by stone wall on which flourished a colony of the purple cliff-brake and the obtuse Woodsia. The nearest rocks on which these ferns would naturally grow were several miles away. It does not seem likely that they were planted there by man, and they must have sprung from spores carried by the wind.

Quite different from the sporangia just described are those of the Osmundaceæ, the family to which the royal fern belongs. In this family the spore-cases are borne on parts of the frond which are reduced to little more than the veins, and form clusters, as shown in the illustration, instead of dots on the under side of the frond. They are also much larger and are very short-stalked. Instead of a jointed ring we find near the base of the sporangium a small group of thick-walled cells, the mere rudiments of a ring. The spores are green and are

larger than those of the other ferns. If they do not fall upon some suitable spot, they die in a few days. There may be some connection between this fact and the large amount of chlorophyll, or green coloring-matter, in them, for the spores of many other ferns, which contain very little of it, remain alive for months or even years.

Sporangia of *Osmunda regalis*. ×5½. (Reprinted from "The Plant World.")

In the damp woods of the tropics, where there is always an abundance of moisture and the air is laden with carbonic acid from the decaying vegetation in the soil, the conditions are most favorable for the growth of all sorts of small plants upon the branches of the trees. Among these "epiphytes," or "plants upon plants," are many species of ferns. In the United States we have two representatives of the filmy fern family, or Hymenophyllaceæ, most of whose members belong to the class of epiphytes.

The filmy ferns differ from our other ferns in the shape of the spore-cases and the way in which they are borne. The ring runs completely around, and is horizontal, so that the sporangium opens lengthwise instead of

across as in the polypody family. They are borne on a vein, but not at the surface of the frond, as in most ferns. Instead, the vein is prolonged into a sort of bristle that springs from the bottom of a sort of funnel- or cup-shaped hollow at the edge of a lobe. This can be seen quite well in the illustration of the sori of *Trichomanes* on page 56.

Sporangium of *Trichomanes*. Enlarged. (After Underwood.)

Still another type of sporangium is found in the Schizæaceæ, a family represented here by only two species—the curly-grass and the climbing fern. They are stray members of a large tropical and subtropical family. The egg-shaped spore-cases are not stalked. Each has a complete ring surrounding the apex. They open by a slit running from end to end.

Sporangium of *Lygodium*. Magnified.

Finally we have the Ophioglossaceæ, or adder's-tongue family, including the adder's-tongue and the grape-ferns, which are unlike the true ferns in some ways. The spore-cases of the latter are developed from cells of the epidermis or outer layer, but in this family they arise in the inner tissues. In the grape-ferns they appear as globular bodies upon the branched summit of a special stalk. There is no ring. The sporangia of the adder's-tongue remain more or less embedded in a straight, unbranched stalk.

Besides this they produce only one frond a year, and even this frond unfolds in a different way from those of the true ferns; or perhaps we should say that they are arranged differently in the bud. Every one who goes to the

woods in spring and early summer is familiar with the "croziers," or uncoiling fronds of the ferns. If we examine

Sporangia and Spores of Grape-fern (*Botrychium*). ×5½.

Sporangia of Adder's-tongue (*Ophioglossum*). ×1½.

them before they come above ground, we will see that the entire frond is wound in a compact spiral with a protective covering of scales or hairs. Even the largest fronds are developed from such buds by the uncoiling and expansion of all the parts. The peculiar shapes assumed by some of our ferns as they are springing up are quite characteristic, among the most familiar forms being the "fiddle-heads"

of the cinnamon-ferns in the swamps, the "turkey-feet" of the brake, and the fronds of the Christmas fern.

Uncoiling Fronds.

The photograph of a bud of the rattlesnake-fern,

one of the grape-ferns, split lengthwise, shows as near an approach to coiling as we ever come across in this fam-

"Fiddle-heads."

ily. The top is simply folded over, and it is all packed into a hollow at the base of the stalk of the previous year's frond. In the illustration the large bud, gathered in 1902, was all ready for the next year. Not only that, but the fern was so "forehanded" as to start along the fronds for 1904 and 1905, which can also be seen indistinctly. The frond for 1903 is folded over to the right, and the one for the next year to the left, so that the fronds face in opposite directions in successive years.

The Development from the Spore.—The mystery of the reproduction of ferns was an insoluble one to ancient botanists with their imperfect instruments. Even to-day

many people suppose that the fruit-dots on the under sides of the fronds are the result of some disease. Any one with ordinarily good eyesight can see that the sori are made up of separate spore-cases, but the spores were not discovered until 1669. Nearly two centuries elapsed before the functions of the spores, and prothalli, and the organs borne upon the latter were clearly made out.

Section through Bud of Rattlesnake-fern. ×4.

Is it any wonder that there seemed to be something supernatural about these plants? Shakespeare says:

"We have the receipt of fern-seed; we walk invisible."

Naturally such a possession would be valuable, and those who sought it went on St. John's Eve, no doubt with much fear and trembling, and divers prayers and incantations, to catch the precious seeds upon a white napkin or sheet. "They say" was as conclusive an argument then as now, and no one seems to have recorded his failures, or even his doubts, if he had any, concerning this mysterious power of the fern-seed—though, it may be added, we have no record of any one who became invisible by its aid.

The development of the mature fern-plant from the

spore is a most interesting process. As it is best known among the members of the polypody family, we will describe that alone. The spores (*a*) are tiny brown objects, irregularly oval in shape and more or less roughened or ridged on the outside. When allowed to lie upon moist soil for a few days, the spore begins to germinate. The brown coat bursts and a long tube divided into cells by cross-partitions and containing grains of chlorophyll, the green coloring matter of plants, springs from it (*b*). "Rhizoids," or root-like hairs, arise here and there and serve to attach the young plant to the soil. Soon the end of the tube flattens out and begins to form a tiny, heart-shaped patch of green tissue (*c*, *d*). This *prothallus*, as it is called, is less than one third of an inch across when fully developed. On the under side are numerous root-hairs and the organs of reproduction, which are of two kinds, the *antheridia* and the *archegonia*. From the antheridia there come, at the proper time, numerous microscopic spiral bodies, called *antherozoids*, that swim rapidly in the drop of water that is necessary for the act of fertilization. One of them enters the opened archegonium and unites with a certain cell known as the *oöspore*, or egg-cell. This then enlarges and divides into four other cells from which, by further subdivisions, arise the root, stem,

Fern-spores. *a*, a spore; *b*, *c*, and *d*, successive stages of germination Much magnified.

Prothalli and Young Plants of Lady-fern. × 3.

Page 30.

first leaf, and foot. The foot remains attached to the prothallus, and through it the young plant receives a certain amount of nourishment until it is able to shift for itself. The illustration on the opposite page shows prothalli and young plants with one or more leaves.

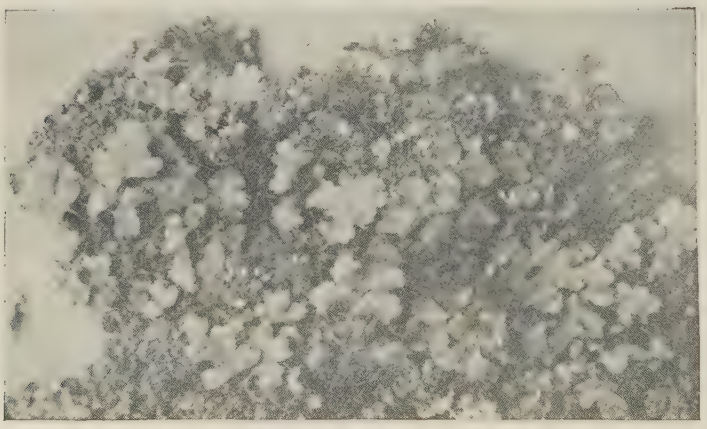
Although there are several archegonia on the prothallus, it rarely happens that more than one fern-plant is developed from it. If two were developed, both would probably be weaklings unable to survive in the struggle for existence.

As with all other plants, Nature provides for very many more young ones than ever come to maturity. Lindley calculated that a single frond of the hart's-tongue fern produced about 18,000,000 spores, and, as suggested by Underwood, the spores of the cinnamon- and rattlesnake-ferns "must far exceed this computation." We once counted about 2100 fruit-dots on a single frond of the marginal shield-fern, and making a fair estimate of the number of spore-cases and spores to a dot, the entire plant produced about 52,000,000 spores. It is evident that only one spore in millions can ever produce a mature plant.

Where to Look for Prothalli.—The best place to look for fern-prothalli is on the moist, steep banks of small streams, where the overhanging foliage keeps off the direct rays of the sun. Those in the illustration on page 30, which are probably young lady-ferns, were obtained in just such a place where the stream had cut in on one side, leaving a low, perpendicular bank of nearly bare earth. It was noticed that many of the prothalli were covered on the under side with minute dew-drops, which must play a part

in the act of fertilization. It is not known whether this moisture is secreted by the prothalli or simply deposited on them, as dew is, from the moist air. Certain kinds of liverworts are apt to be mistaken for prothalli. Indeed, the very name "prothallus" comes from the resemblance to the "thallus" of liverworts.

The earliest fronds are alike, or nearly so, in most of our species, so that one must be cautious in naming a fern when it is very small. The safest way is to select the specimens from a spot where only one species is growing, or else to raise them from the spores.



Young Ferns. (Natural size.)

Raising Ferns from Spores.—The spores may be scattered over the surface of rich earth contained in a deep flower-pot saucer, or a flower-pan, which is kept moist by setting it in a plate with a little water. A pane of glass with a piece of thin white paper pasted over it serves a double purpose in screening from the sun and keeping a moist atmosphere around the prothalli. In a week or

less the spores should begin to germinate, though it takes a long time to obtain new plants in this way. Prothalli and young plants are frequently seen on the outside of flower-pots in greenhouses, and following out such a suggestion a gardener in Florida sowed spores on bricks kept in a pan of water, according to a note in the "Fern Bulletin." Plants obtained in this way exhibited many abnormal variations.

If one wants to study the earlier stages of germination under the microscope, the best way we have been able to devise is to sow the spores upon a piece of filter-paper pressed down upon moist earth in a flower-pan set in a plate containing water. A bit of the paper with the attached spores is cut off, laid upon a drop of water to wash off the under side, and then transferred to the glass slide for examination. Earth is better than sand since it supplies more of the materials needed by the young plants. We have never carried on these experiments for more than a few weeks at a time, so we are unable to say whether the prothalli can be brought to maturity or whether the young plants, if produced, can push their roots through the paper. It seems probable that they will be able to do so, for they can grow upon compact earth which the roots must penetrate.

Hybrid Ferns.—The pollen of flowers goes astray at times, producing hybrids or "crosses," and one might naturally ask what would happen if some antherozoids should wander across a convenient drop of water to a near-by prothallus of some other species. Of course, if

the two prothalli belong to widely different ferns no fertilization can take place, but if they are closely related species there is a possibility of the production of a hybrid. The chances are rather against it, for the rightful antherozoids would have the preference if both kinds should enter the archegonium simultaneously.

There are two or three species of ferns within our limits that are regarded by some botanists as hybrids. Experiments have been made to produce these species artificially, and with marked success in two cases. Miss Margaret Slosson used the method, suggested by Mr. G. E. Davenport, of cutting the prothalli into strips, and planting sections bearing antheridia and archegonia of different species in contact. In this way she succeeded in producing a cross between the marginal and crested shield-ferns which is just like the natural form. More recently she has settled a discussion regarding the hybridity of Scott's spleenwort by producing it from the two species long supposed to be its parents.

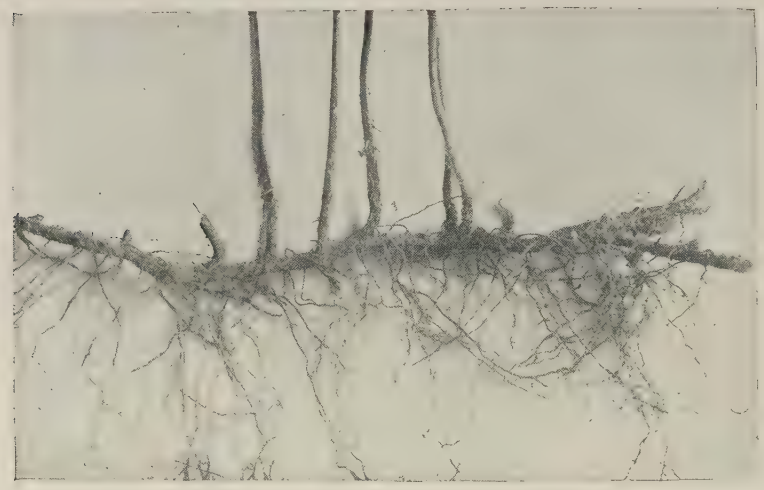
Apogamy and Apospory. — We have seen how the spore gives rise to the prothallus which bears on its under side the archegonia and antheridia. It has been observed in a few cases that a fern-plant may develop from the prothallus by budding, without the intervention of the organs of fertilization, although the buds are produced from the part of the prothallus where the archegonia are usually found. This is known as "apogamy." In the case of a common greenhouse fern (*Pteris cretica*) the archegonia are apparently never formed.

At times prothalli, normal in other respects, are formed upon the fronds and there produce young plants. This "apospory" has been noticed in a few species.

Pinna of the Common Brake showing Apospory ×5½.

Other Means of Reproduction.—One of the commonest ways in which ferns increase in number is by rootstocks that send forth branches which finally break their connection with the parent. In the illustration is shown a rootstock, or "rhizome," of the broad beech-fern. The bases of the stalks of the season's fronds are shown, and beyond them the new growth of the year. In about three

years the old rootstock would have decayed up to the junction of the two branches, thus separating them into two individual plants. In some species the rootstocks



A Creeping Rootstock of the Broad Beech-fern. ×½.

may creep several feet in a season, and in this way can rapidly cover the ground when they have once become established.

It will be noticed in the illustration on this page that the old stalks die down nearly or quite to the rootstock, while the rudimentary fronds for the next season are little more than knobs on its newer part. From this we find all variations to rhizomes like that of the lady-fern, which is short and covered with the undecayed bases of the stipes of several years. At its growing end are coiled up the undeveloped fronds for one or two years ahead.

All the types of rootstocks probably serve as storehouses for food material which is prepared during the sum-

Rootstock of the Lady-fern. (Natural size.)

The same, split lengthwise.

mer so as to give the plant a good start the next spring. In the long, creeping ones there is sufficient room, and the

same is true of the grape-ferns and adder's-tongue, which have a very short rhizome, but quite thick roots which are packed with starch, in which form most plants store up food. In the case of the lady-fern rootstocks, and others of the same type, the storage-space is increased by the undecayed bases of the old stipes. The second of the illustrations on page 37 shows one in which the oldest stipe-bases are six or seven years old, but still sound and packed with starch.

Two other methods of reproduction must be mentioned, though they will be discussed more fully when the ferns are taken up in a later chapter. The formation of bulblets on the rachis and midribs of the pinnæ is familiar to those who know the bulbiferous bladder-fern. From this it seems an easy step to the tropical ferns which produce young plants on the fronds. The other method is illustratrated by the walking-fern, that has a greatly prolonged tip which readily takes root and gives rise to a new plant.

CLASSIFICATION OF OUR FERNS

"If it were required to know the position of the fruit-dots or the character of the indusium, nothing could be easier than to ascertain it; but if it is required that you be affected by ferns, that they amount to anything, signify anything to you, that they be another sacred scripture and revelation to you, helping to redeem your life, this end is not so easily accomplished."—THOREAU.

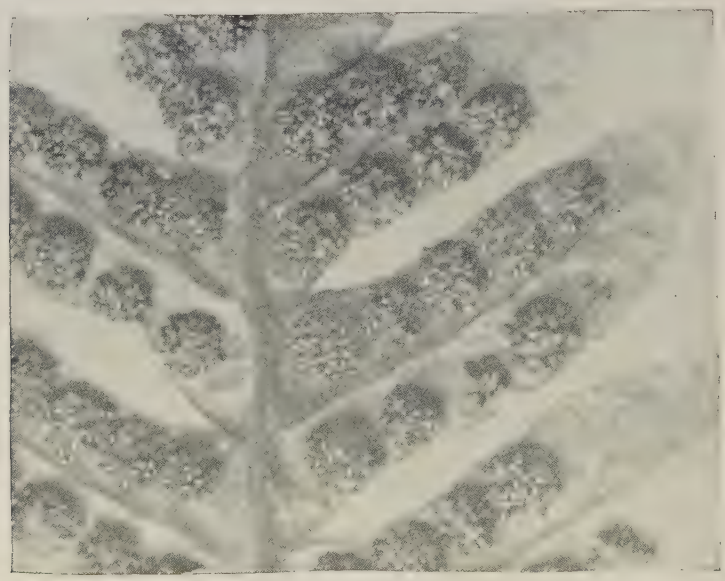
FERN FAMILIES.

IN the chapter on Reproduction a brief account was given of the characteristics of the five families represented within our limits. The character of the spore-case determines the family to which any fern belongs. In each family we find representatives of one or more genera. The latter are classified principally according to the shape of the sori, the venation, etc. We will state briefly the characteristics of the genera to which the ferns around us belong. The illustrations are, with two or three exceptions, photographs made from fresh specimens, and enlarged as they were taken, by the method described in the chapter on Fern Photography.

FERN GENERA.

In the polypody family are most of the genera we shall meet with. The spores are brown in all our species.

1. *Polypodium.*—Sori round, on the ends of veinlets on the under side of the frond; without indusium or cover-



Sori of *Polypodium vulgare.* ×5½.

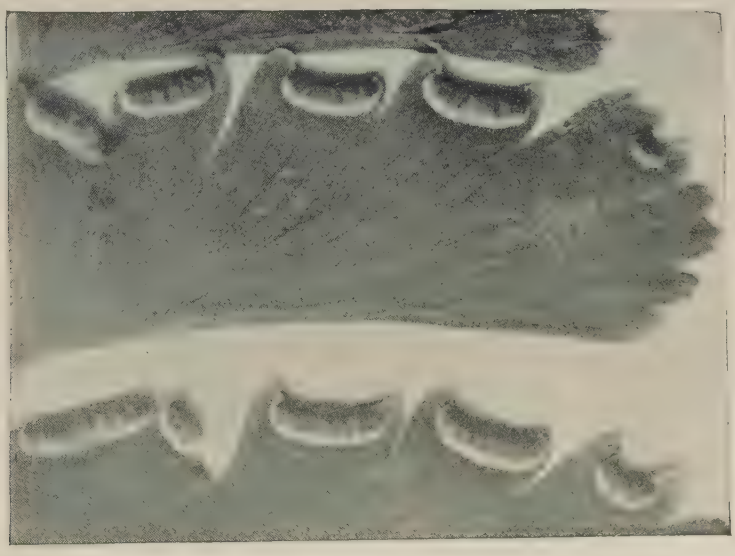
ing of any kind. Stipes articulated to the rootstock, that is, leaving a distinct scar when broken off. We have two species.

Sori of *Notholæna.* ×5½.

2. *Notholæna.*—Sori short, of few large spore-cases, without indusium, placed near the tips of the veins. Under surface of the frond chaffy, woolly, or powdery.

There are thirty or forty species in this genus, but only one within our limits.

3. *Adiantum.*—Sporangia at the ends of the veins on a reflexed portion of the margin. The sori are thus on the under side of the indusium. There is no midrib to the



Sori of *Adiantum pedatum.* ×5.

pinnules, and the forking veins spread out like the ribs of a fan, or else spring from the lower margin of the pinnule.

There are two species within our limits.

4. *Pteris.*—Sporangia on a continuous vein running around near the margin, which is bent over to form the indusium. The single species we have has a second, obscure indusium under the sporangia, and for that reason it is placed in a separate genus, *Pteridium*, by some authors.

At first the sporangia are completely hidden by the indusium, but as they develop they push it back and then

appear as a continuous brown line around the margins of the lobes.

Young Sori of *Pteris aquilina.* ×5.

We have a single species.

5. *Cheilanthes.*—Sporangia near the ends of the veins. Indusia, in our species, formed of the ends of the roundish lobes, and soon pushed back by the enlarging sporangia.

There are four species within our limits, all but one being more or less hairy.

6. *Pellæa.*—Sporangia borne on the ends of the veins and covered with an indusium formed of the reflexed mar-

Old Sori of *Pteris aquilina.* ×5½.

gin. Just as in *Pteris* the sporangia finally push back the indusium.

We have two species.

7. *Woodwardia.*—Sori oblong or linear, borne on veinlets parallel to the midrib, thus forming a chain-like row. Indusia attached to the same veins and opening toward the midrib.

Our two species belong to two sections of the genus, distinguished by the character of the venation.

Sori of the Alabama Lip-fern. $\times 5\frac{1}{2}$.

8. *Asplenium.*—Sori elongated, on the upper sides of the veins, and covered with indusia which are attached to the same veins and open toward the midvein. The sori are straight or slightly curved.

Most of our ten species are small, rock-loving plants.

9. *Athyrium.*—Sori and indusia much as in *Asplenium*, but rather more curved, and many of them crossing the

veinlet. When this is carried to the limit we have two sori placed back to back on the veinlet.

Young Sori of *Pellæa atropurpurea*. ×5.

Our two species are still kept in the genus *Asplenium* by some botanists.

10. *Scolopendrium*.—Sori linear, facing one another in pairs from opposite sides of two adjacent veinlets. Indusia folded toward each other and meeting at their edges; at length forced back by the sporangia.

We have but one species.

11. *Camptosorus.*—Sori oblong or linear, and covered with indusia as in *Asplenium*, but placed on either side

Sori of *Woodwardia Virginica.* ×5½.

of the veins, which form an irregular network. Many of the sori are much bent or even forked as shown in the illustration.

We have a single species.

12. *Phegopteris.*—Sori round and without indusium, as in *Polypodium*, but on the back (not the ends) of the veins. Stipes not articulated to the rootstock.

There are four species within our limits.

13. *Nephrodium.*—Sori round, on the back of a veinlet (seldom at the end). Indusia roundish-reniform, attached

Sori of *Asplenium ebeneum.* ×5.

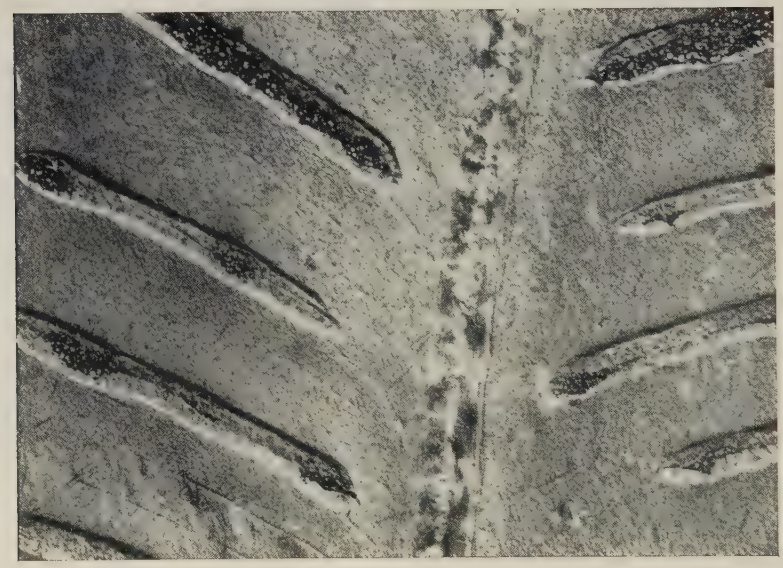
Sori of *Athyrium thelypteroides.* ×4.

by the center or by the sinus. Veins free. Stipes not articulated to the rootstock.

The species of this genus and the next are classed under *Aspidium* and *Dryopteris* by some botanists. There are several species and varieties within our limits.

14. *Polystichum.*—Sori, veins, and stipes as in *Nephro-*

dium. The indusium differs in being peltate, that is, circular and attached by the center.



Young Sori of *Scolopendrium vulgare.* ×5.

We have two or three species.

15. *Cystopteris.*—Sori roundish, borne on the back of the veins. Indusium very thin, hood-like or arched, attached by a broad base partly under the sorus; free at the other side; soon withering.

There are two species within our limits.

16. *Onoclea.*—Sori round, on the back of the veins of the much contracted fertile frond, the lobes of which form little berry-like divisions filled with sporangia. Indusia very thin, attached on the lower side of the sorus. Sterile fronds with veins forming a network. The indusia are

best seen in the curious form known as *Onoclea sensibilis obtusilobata*.

We have one species.

Sori of *Camptosorus rhizophyllus*. ×5½.

17. *Struthiopteris*.—Sori round, borne on the backs of the veins of the much contracted fertile frond, which has pod-like pinnæ. Veins of the sterile fronds free.

We have but one species.

18. *Woodsia*.—Sori round, borne on the back of the free veins. The very thin, often evanescent indusium is

attached by its base beneath the sporangia. It is either small and open, or else early bursting into irregular pieces or lobes.

Sori of *Phegopteris hexagonoptera*. ×5½.

In one of our species the indusium splits into a few broad lobes; in the other five it is divided into slender hairs.

19. *Dicksonia*.—Sori small, globular, marginal, each on the apex of a free vein. The sporangia borne on an elevated globular receptacle, and enclosed in a thin, cup-shaped indusium which is open at the top, and on the

Sori of *Nephrodium marginale.* ×5.

Sori of *Polystichum acrostichoides.* ×3½.

outer side partly adherent to a reflexed toothlet of the pinnule.

There is only one species within our limits.

Sori of *Cystopteris fragilis*. ×5½.

Fertile Frond of *Onoclea sensibilis*. (Natural size.)

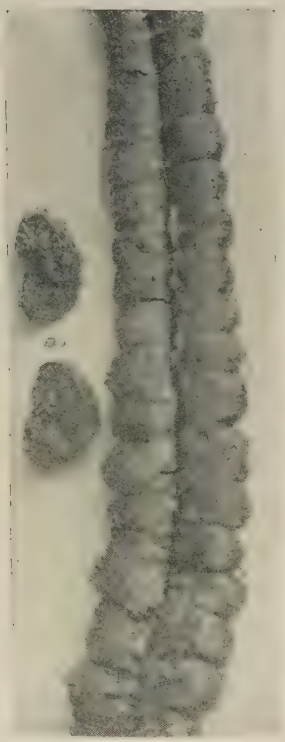
20. *Trichomanes*.—Sori marginal, terminating a vein, and more or less sunken in the frond. Spore-cases sessile on a thread-like receptacle, the continuation of a vein, surrounded by the cup-shaped indusium, which is two-lipped at the mouth.

A large genus of mostly tropical ferns, of which we have one species within our limits.

21. *Schizœa.*—Sporangia large, ovoid, vertical, sessile in a double row along the single vein of the narrow divisions of the fertile appendages to the slender, simple fronds.

We have but a single species.

Part of a Pinna of *Onoclea sensibilis obtusilobata*, showing indusia. ×4. Reprinted from "The Plant World."



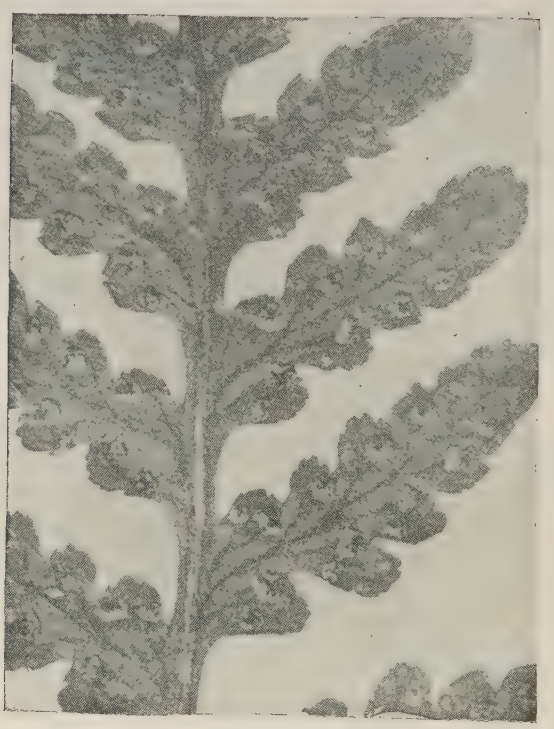
Part of Fertile Pinna of *Struthiopteris Germanica*. *a*, cross-sections of pinna. ×4.

22. *Lygodium.*—Sporangia ovoid, solitary or in pairs, in the axils of large, imbricated, scale-like indusia which are attached by a broad base to the short veinlets of the contracted fertile pinnæ.

We have a single species.

We have one representative of this genus of climbing-ferns.

The *Osmunda* family is represented by only three species within our limits. They all belong to the same genus.



Sori of *Woodsia obtusa*. $\times 5\frac{1}{2}$.

23. *Osmunda*.—Sporangia large, globular, short-stalked, with a rudimentary ring; borne on the margin of rachis-like divisions. Spores green.

On page 23 is shown a photograph of the sporangia of *O. regalis*. The other two species have the spore-

Sori of *Dicksonia pilosiuscula*. ×5.

cases more densely clustered, as shown in the photograph on page 57.

Finally we have two genera belonging to the adder's-tongue family. Illustrations of the sporangia of *Botry-*

Sori of *Trichomanes radicans*. $\times 5\frac{1}{2}$.

chium and *Ophioglossum* have been given on page 25.

24. *Botrychium* —Sporangia distinct, in pinnate or com-

pound spikes at the summit of a special stalk. Veins free. Spores yellow.

We have about ten species and varieties.

Fertile Fronds of *Schizæa pusilla*. ×5½.

25. *Ophioglossum*.—Sporangia cohering in a simple spike. Veins forming a network. Leafy portion simple in our species. Spores yellow.

Stress must be laid upon the statement that the only satisfactory and scientific method of classifying the ferns is based on the fructification. With the knowledge of the families and genera that has been gained in the pages

Fertile Pinnæ of *Lygodium palmatum*. ×5.

that precede, the beginner will be able to use the key given in the next chapter. The conclusion arrived at should always be verified by consulting the more detailed description given later under the species.

Mistakes may be frequent at first, for it is only by constant study and observation that one can come to know the ferns in all their varied forms.

Part of Fertile Frond of *Osmunda cinnamomea*. ×5½.
Reprinted from "The Plant World."

ANALYTICAL KEY

BASED ON THE FRUCTIFICATION

AS we have already said, it is not necessary to have fruiting specimens in order to determine the names of our ferns, if the analytical key based on the stalks, which is given in the next chapter, be used. However, there are many who might like to go about it in the truly scientific way, and for them the following key has been arranged. It is based on the ones given in the familiar manuals. To avoid repetition, the descriptions of the families and genera which are given in the preceding chapters are simply referred to.

POLYPODIACEÆ. (Page 20.)

A. POLYPODIEÆ. Sori round, on the back of the frond, at the ends of the veins, in our species. Stipes articulated to the rootstock.

I.—*Polypodium* (page 40).

P. vulgare. Lower surface green, smooth (p. 77).

P. incanum. Lower surface densely scaly, grayish (p. 83).

B. GRAMMITIDEÆ. Sori more or less elongated, without indusium, placed usually along the veins or near their extremities.

II.—*Notholæna* (p. 40).

N. dealbata. Small, triangular-ovate, tripinnate, powdery beneath (p. 85).

C. Pteridæ. Sori marginal, with an indusium formed of the reflexed margin of the frond.

III.—*Adiantum* (p. 41).

A. pedatum. Dichotomously forked, with pinnate branches (p. 88).

A. Capillus-Veneris. Fronds bipinnate (p. 91).

IV.—*Pteris* (p. 41).

P. aquilina. Large, coarse, ternate, with nearly equal branches (p. 93).

V.—*Cheilanthes* (p. 42).

C. Alabamensis. Fronds nearly smooth, bipinnate (p. 98).

C. vestita. Fronds hairy and glandular, not woolly. Indusia not continuous (p. 100).

* Fronds more or less woolly. Indusia mostly continuous.

C. tomentosa. Fronds six to eighteen inches long; stipes stout, densely brown-woolly (p. 108).

C. lanuginosa. Fronds two to six inches long, stipes slender, at length nearly glabrous (p. 106).

VI.—*Pellæa.* (p. 43).

P. gracilis. Small, filmy, bi- or tripinnate, pale green (p. 111).

P. atropurpurea. Pinnate or bipinnate, thickish, dark green (p. 113).

P. densa. Small, tripinnate, the pinnules narrow (p. 118).

D. Blechneæ. Sori oblong or linear, borne on veinlets parallel to the midrib covered with an indusium.

VII.—*Woodwardia* (p. 43).

W. Virginica. Fronds uniform. Veins free between the sori and the margin (p. 121).

W. angustifolia. Fronds of two kinds. Veins all forming meshes (p. 124).

E. Asplenieæ. Sori more or less elongated, on one or both sides of oblique veins, covered with a special indusium attached on one side to the vein.

VIII.—*Asplenium* (p. 44).

* Fronds pinnatifid or pinnate below, tapering to a point.

A. pinnatifidum. Stipe blackish below (p. 130).

A. ebenoides. Stipe and lower part of rachis blackish (p. 133).

** Fronds once pinnate.

† Rachis green.

A. viride. Pinnæ not auricled, small ($\frac{1}{3}$ inch long) (p. 137)

A. angustifolium. Pinnæ 3–4 inches long (p. 159).

†† Rachis brown or blackish.

A. Trichomanes. Pinnæ not auricled, partly alternate, partly opposite (p. 139).

A. resiliens. Pinnæ opposite, oblong, auricled at the upper side of the base. Rachis black or nearly so (p. 142).

A. ebeneum. Pinnæ partly alternate, lanceolate, auricled at the upper side of the base. Rachis chestnut-brown (p. 144).

*** Fronds 2–3-pinnatifid.

A. Bradleyi. Stipe and lower part of rachis brown (p. 150).

A. montanum. Stipe dark at base, green above. Fronds ovate-lanceolate (p. 154).

A. fontanum. Stipe dark at base, green above. Fronds lanceolate, broadest above the middle (p. 158).

A. Ruta-muraria. Stipes green. Fronds ovate-deltoid. Segments fan-shaped (p. 157).

IX.—*Athyrium* (p. 44).

A. thelypteroides. Twice pinnatifid, segments blunt, more or less hairy (p. 163).

A. filix-fœmina. Twice pinnate, pinnules acute, toothed or pinnatifid, smooth (p. 167).

X.—*Scolopendrium* (p. 45).

S. vulgare. Frond simple (p. 174).

XI.—*Camptosorus* (p. 46).

C. rhizophyllus. Fronds simple, long-tapering (p. 179).

E. Aspidieæ. Sori round or roundish, on the back, or rarely at the apex of the vein, with a special indusium, rarely naked. Stipes not articulated to the rootstock.

XII.—*Phegopteris* (p. 46).

P. polypodioides. Triangular, bipinnatifid, longer than broad, dark green (p. 184).

P. hexagonoptera. Triangular, bipinnatifid, as broad as long or broader, light green (p. 189).

P. Dryopteris. Fronds ternate, the divisions nearly equal, often deflexed so as to be horizontal; smooth (p. 194).

P. calcarea. Fronds ternate, the terminal division largest; erect; glandular (p. 196).

XIII.—*Nephrodium* (p. 47).

*** Pinnatifid, thin in texture. Veins simple or once forked.**

N. Thelypteris. Lower pinnæ not much smaller than the upper ones. Veins once forked. Sori crowded (p. 199).

N. simulatum. Lower pinnæ not much smaller than the upper ones. Veins simple. Sori distant (p. 205).

N. Noveboracense. Lower pinnæ much reduced (p. 209).

**** Texture much firmer. Veins forking freely.**

† Fronds bipinnatifid or bipinnate. Segments not bristle-toothed.

N. fragrans. Fronds small, narrowly lanceolate, glandular (p. 213).

N. cristatum. Large. Indusia thin, flat. Pinnæ widest at base (p. 224).

N. Goldieanum. Large. Indusia thin, flat. Pinnæ widest at middle (p. 230).

N. marginale. Indusia convex, without glands on edges. Sori near the margin (p. 236).

N. filix-mas. Indusia convex, without glands. Sori nearer midvein than margin, usually on the lower half of the pinnule (p. 241).

†† Fronds bipinnate or tripinnatifid. Segments bristle-toothed.

N. spinulosum. Ovate-lanceolate, usually not narrowed below. Scales on stipe usually with a dark center (p. 214).

N. Boottii. Elongated-lanceolate, usually narrowed at the base. Scales of the stipe pale brown (p. 221).

XIV.—*Polystichum* (p. 47).

P. acrostichoides. Once pinnate. Lower pinnæ little reduced (p. 244).

P. Lonchitis. Once pinnate. Lower pinnæ much reduced. Stipes short (p. 252).

P. Braunii. Bipinnate (p. 254).

XV.—*Cystopteris* (p. 48).

C. bulbifera. Fronds broadest at base, long-tapering, often bearing bulblets beneath (p. 255).

C. fragilis. Fronds scarcely broader at base, short-pointed, not bearing bulblets (p. 259).

C. montana. Fronds deltoid-ovate, tri- to quadripinnate (p. 262).

XVI.—*Onoclea* (p. 48).

O. sensibilis. Coarse, deeply pinnatifid, broadly triangular fronds (p. 265).

XVII.—*Struthiopteris* (p. 49).

S. Germanica. Fronds tall, bipinnatifid, lanceolate (p. 269).

F. Woodsieæ. Sori round. Indusium fixed under the sorus, divided into segments or into slender filaments.

XVIII.—*Woodsia* (p. 49).

*** Indusium minute, concealed, splitting into slender filaments. Stipes obscurely jointed near the base.**

W. Ilvensis. Fronds with rusty chaff beneath (whitish when young) (p. 273).

W. hyperborea. Fronds smooth or nearly so, lanceolate, not tapering below; pinnæ cordate-ovate, 5–7-lobed (p. 276).

W. glabella. Fronds smooth, linear or linear-oblong, often tapering both ways; pinnæ deltoid (p. 278).

W. Oregana. Indusium hidden by the sporangia; divided to the center into necklace-like hairs. Frond and stipe not hairy or glandular (p. 285).

W. scopulina. Indusium hidden by the sporangia; deeply cleft into narrow segments ending in jointed hairs. Fronds puberulent (p. 286).

**** Indusium distinct, splitting into jagged lobes. Stipes not jointed.**

W. obtusa. Indusium distinct, splitting into jagged lobes (p. 280).

G. Dicksonieæ. Sori roundish, marginal. Indusium cup-shaped or two-valved, the outer portion composed of a reflexed lobe of the pinnule, or more or less united with it.

XIX.—*Dicksonia* (p. 50).

D. pilosiuscula. Fronds ovate-lanceolate, often long taper-pointed, usually tripinnatifid (p. 286).

HYMENOPHYLLACEÆ. (Page 23.)

XX.—*Trichomanes* (p. 52).

T. radicans. Fronds small, very thin and filmy, bi- to tripinnatifid (p. 296).

SCHIZÆACEÆ. (Page 24.)

XXI.—*Schizæa* (p. 53).

S. pusilla. Fronds filiform, the fertile ones with about five pairs of crowded pinnæ in a terminal spike (p. 291).

XXII.—*Lygodium* (p. 53).

L. palmatum. Twining. The alternate branches two-forked, each fork with a 4–7-lobed pinnule (p. 292).

OSMUNDACEÆ. (Page 22.)

XXIII.—*Osmunda* (p. 54).

O. regalis. Fronds bipinnate. Fertile pinnæ at the apex (p. 298).

O. Claytoniana. Fronds bipinnatifid. Pinnæ without tufts of wool at the base. Fertile pinnæ at the middle of the frond (p. 303).

O. cinnamomea. Fronds bipinnatifid. Pinnæ with a tuft of wool at the base. Fertile frond separate from the sterile (p. 307).

OPHIOGLOSSACEÆ. (Page 24.)

XXIV.—*Botrychium* (p. 57).

* Bud for the next year completely enclosed in a cavity at the base of the stem.

† Leaf sessile or nearly so at or above the middle of the stem.

B. Lunaria. Frond with fan-shaped segments. Fertile part not bent over in the bud (p. 315).

B. matricariæfolium. Pinnatifid or bipinnatifid with narrow divisions (p. 322). Both parts bent over in the bud.

B. tenebrosum. Frond entire, or with a few pairs of distant, lunate, decurrent lobes (p. 324).

B. lanceolatum. Frond triangular, bipinnatifid, sessile. Fertile part recurved in the bud (p. 320)

†† Leaf rising near the base of the stalk.

B. simplex. Bud smooth. Leaf entire or few-lobed. Parts straight in the bud (p. 319).

B. obliquum and *varieties.* Bud hairy. Frond large, ternate, long-stalked. Parts inclined in the bud (p. 327).

** Bud-cavity open at one side.

B. Virginianum. Frond ternate, sessile at the middle of the stem, much divided (p. 337).

XXV.—*Ophioglossum* (p. 57).

O. vulgatum. Leaf simple, ovate or elliptic, sessile at the middle of the stalk (p. 341).

THE ANALYTICAL KEY

BASED ON THE STALKS

OW to Use the Key.— It is only necessary to have a sharp penknife and a good pocket-lens in order to determine the ferns by means of the key. The fern to be studied should be carefully picked so as to obtain the entire stipe, and it should not be allowed to wither, for in that case grooves may appear that do not properly belong to it. The identification of the species depends largely on the grooves and ridges, as well as upon the number of fibrovascular bundles. When the ferns are small, it is best to select as large a frond as possible, for it is not only easier to study the stem, but they may happen to be young specimens of a large species,—the nearer they are to the average size the more certain is the identification, although a series from the smallest up to the largest fronds was studied in working out the key, and their variations were taken into account.

In nearly every fern the extreme lower part of the stipe is quite different in size, shape, and color from the upper

part. The "typical" cross-section is made by cutting squarely across the stalk just above this basal part. The cut ends of the fibrovascular bundles are seen as dots or lines, usually lighter in color than the surrounding tissues. When a bundle is said to be round, or oval, or flat, it means, of course, that the dot is of this shape.

The number of bundles depends to some extent on the size of the stipe and where it is cut. The higher up we go, or the smaller the stalk, the fewer the bundles. This has necessitated the numerous cross-references in the key. The sheath of black tissue surrounding the bundle in many ferns is often quite prominent, but it was not found practicable to utilize it in the key, since it is not present in all stems of the same species. It is frequently difficult to see the ridges and grooves, but by slowly turning the stem while facing a bright light they can be made out.

For the sake of exactness the following definitions have been adhered to in the key. The *stipe* is that part of the stalk which is below the leafy portion. The *rachis* is the continuation of the stipe, unless the frond be simple, when the term *midrib* is used. The stipe and rachis together are spoken of as the *stalk*. The *front* of a stalk is on the side toward the upper surface of the frond. The opposite side is the *back*. *Above* and *below* mean near the tip and base of the stalk, respectively.

The key deals chiefly with the stalks, but in the next chapter full descriptions of the different species are given. The drawings in this chapter are merely intended to give an idea of what to look for in a cross-section of a stem.

ANALYTICAL KEY

A. ONE BUNDLE.

I. Bundle Decidedly Curved.

* Bundle more or less rolled up or folded at the ends.

1.—*Osmunda cinnamomea*, and var. *glandulosa* (p. 307). Stalk green, often reddish below in large specimens. Rachis and upper part of stipe narrowly 2-winged or ridged. Small stipes often have traces of grooves in front.

2.—*Osmunda Claytoniana* (p. 303). Much like No. 1, but the entire stipe is 2-ridged. Large stalks have traces of grooves in front.

Cross-section of No. 1.

3.—*Osmunda regalis* (p. 298). Stalks dark, rather hard. Rachis is 2-winged above.

4.—*Adiantum pedatum* (p. 88). Stalks very dark brown, polished, wiry; slightly grooved in front, below. Ends of bundle not much rolled up.

** Bundle not rolled up at the ends.

5.—*Botrychium ternatum* and *var.* (p. 327). Stalks very soft, reddish. Divisions of rachis and upper part of stipe grooved in front. Bundle almost or quite curved into a ring below; above, dividing into 2–4.

6.—*Pellæa gracilis* (p. 111). Stipe brown, slender. Rachis green (or brownish below). Stalk deeply grooved in front. Stipe laterally grooved. Grooves less distinct below. In small stipes the bundle is a mere dot, and at times it is barely curved.

Cross-sections of No. 5

7.—*Pellæa atropurpurea* (p. 113). Stalk very dark brown, wiry, brittle shining but roughish, and having light brown or whitish pubescence; no grooves or ridges.

8.—*Dicksonia pilosiuscula* (p. 286). Stalk green or yellowish, except towards the brown base; glandular-pubescent throughout; grooved in front to base, and on sides nearly to base; shining, but roughened by minute projections.

Cross-section of No 7

Small specimens of Nos. 28 *to* 39 *may fall under this section.*

II. Bundle V- or X-shaped.

Small specimens of Nos. 13 *to* 25, *and* 40, *or sections taken too far above the base may fall under this heading.*

III. Bundle Oval or Round.

9.—*Asplenium Trichomanes* (p. 139). Stalk very dark brown, polished. Rachis and nearly the entire stipe ridged on the sides, flattened in front.

Cross-section of No. 9.

10.—*Asplenium viride* (p. 137). Stalk reddish-brown at base, green above; somewhat flattened in front, below; above deeply grooved. Stipe somewhat flattened laterally, and with traces of grooves that become more marked in the rachis.

11.—*Schizæa pusilla* (p. 291). Stalk very slender, green (brownish when old), grooved in front (except in very small specimens) to the brown base, where it is more slender and flattened. Two very slight grooves at the back are marked by two dotted lines.

12.—*Lygodium palmatum* (p. 292). Stalk light brown or yellowish, except at base; slender, twining, slightly flattened in front.

See also Nos. 6, 41, 42.

B. TWO BUNDLES.

I. Bundles nearly joined in a Ring.

See Nos. 5, *and* 46 *to* 51.

II. Bundles Round or Oval at Extreme Base, flattening and approximating to form a V or X very near the Base of the Stipe.

(Nos. 13 to 20 have bundles as in No. 18.)

13.—*Asplenium pinnatifidum* (p. 130). Lower half or two-thirds of stipe brown and shining, green above. Rachis and upper part of stipe broadly winged. Stipe flattened in front, below; higher up, with a broad groove; flattened, and with traces of grooves on sides.

14.—*Asplenium Ruta-muraria* (p. 157). Stalk green, except at extreme base; deeply grooved in front to extreme base, with slight lateral grooves (or none in very small specimens).

15.—*Asplenium montanum* (p. 154). Stipe brown at base, green above. Rachis and upper two-thirds of stipe flat, with two parallel grooves in front.

16.—*Asplenium Bradleyi* (p. 150). Stipe and lower part of rachis brown. Stalk grooved in front, except toward flattened base, with a slight ridge down the center of groove.

17.—*Asplenium resiliens* (p. 142). Stalk black, shining, flattened in front, below. Stipe very short, with two ridges that run into the pale brown ridges, or narrow wings, of the rachis.

18.—*Asplenium ebeneum* (p. 144). Stalk dark brown, polished, stipe very short, not flattened, grooved, or ridged. Rachis grooved in front, and with two lateral ridges (except near base) from which the pinnæ spring.

19.—*Asplenium ebenoides* (p. 133). Stipe and lower part of rachis dark brown, polished. The green wings of the rachis run into two lateral ridges in the upper part of stipe, which thus appears 2-grooved in front.

Cross-section of No. 18.

20.—*Camptosorus rhizophyllus* (p. 179). Stipe brown at base, green above, flattened on three sides; slightly grooved laterally, and 2-grooved in front, above.

21.—*Cheilanthes vestita* (p. 100). Stalk brown, shining, but thickly clothed with 1–6-celled hairs (which appear jointed under a lens); articulated to rhizome; not grooved or ridged. Two bundles rarely seen.

Cross-section of No. 21.

22.—*Woodsia glabella* (p. 278). Stipe articulated above base, with a few pale scales below joint, smooth above. Stalk green or yellowish except at extreme base, smooth, grooved in front nearly to base. Bundles as in No. 25.

23.—*Woodsia hyperborea* (p. 276). Stipe articulated above base. Stalk more or less hairy, black at base; brown, shading to yellowish above. Bundles as in No. 25.

24.—*Woodsia Ilvensis* (p. 273). Stipe articulated above base. Stipe and under side of rachis scaly. Stalk flattened and grooved in front to the joint or below; brown below, shading to green above. Bundles as in No. 25.

25.—*Woodsia obtusa* (p. 280). Stipe not articulated. Stalk brown at base, green or yellowish above, with pale scales and glandular pubescence. Rachis and upper part of stipe grooved in front and often with traces of lateral grooves. Stalk usually marked with two green lines. Bundles very soon uniting into a sort of curved V.

Cross-section of No. 25, some distance above the base.

III. Bundles Roundish, not soon uniting into a V or X.

26.—*Phegopteris Dryopteris* (p. 194). Stipe slender, translucent, smooth except at dark-brown base. Black tissue surrounding bundles is very evident through the stalk. Stipe slightly flattened below, grooved in front, above. Ternate rachis deeply grooved in front.

27.—*Cystopteris fragilis* (p. 259). Stalk slender, weak, brown below, green above, smooth; with lateral grooves (often absent in small specimens); grooved in front, except at the flattened base. Rachis narrowly winged.

28.—*Woodwardia angustifolia* (p. 124). Stipe dark brown and tapering at base, green or straw-colored in the sterile fronds above, with scattering brown scales; flattened (and rarely with traces of grooves) in front; laterally ridged.

See also Nos. 41 *and* 42.

IV. Bundles Oval or Flat (curved in No. 40).

* Bundles usually less than $2\frac{1}{2}$ times as long as broad.[1]

29.—*Nephrodium Noveboracense* (p. 209). Stalk grooved in front, slender. Rachis flattened on sides, with slight grooves. Stipe less flattened and with traces of grooves. Bundles about 2×1, bridged.[2]

"Bridged" Bundles of No. 29.

30.—*Nephrodium simulatum* (p. 205). Stalk weak, pubescent. Rachis distinctly 3-grooved. Stipe similarly grooved above; the lateral grooves extend to the dark base; lower half, or less, flattened, and with traces of two grooves in front. Bundles as in No. 29.

31.—*Nephrodium Thelypteris* (p. 199). Stalk 3-grooved, except at base, where it is flattened on three sides; pubescent. Bundles not bridged, $1\frac{1}{3}\times1$. Veins forked.

32.—*Cystopteris bulbifera* (p. 255). Stalk weak, translucent, pale green (often pinkish), shading to brown, below. Rachis and upper part

[1] Written $1\frac{1}{2}\times1$ and $2\frac{1}{2}\times1$, etc., in the descriptions.

[2] In section IV some of the bundles coalesce at a distance above the base and form a curved bundle. In others they become united by a straight connective joining one end of each. We shall call the latter "bridged" bundles.

of stipe grooved in front, flattened and with traces of grooves on sides. Stipe flat in front, below. Bundles about 2×1, not bridged. Rachis and midribs often bulbiferous beneath.

33.—*Phegopteris hexagonoptera* (p. 189). Stipe slightly flattened in front, and with a light-green line on each side (except in forms approaching No. 34); often with traces of front and lateral grooves. Bundles uniting rather soon, bridged.

34.—*Phegopteris polypodioides* (p. 184). Stipe usually rather dark above, pubescent, flattened in front, and usually grooved. Bundles as in No. 33.

** Bundles usually more than 2½ times as long as broad.

35.—*Asplenium angustifolium* (p. 163). Stalk green with brown pubescence; black at extreme base, where there is a dense sheath of hairs; deeply grooved in front. Rachis flattened laterally above, grooved below. Stipe grooved in front, except at 2-ridged base. Rachis narrowly 2-winged near top.

36.—*Athyrium filix-fœmina* (p. 167). Stalk green or reddish, smoothish, 3-grooved nearly to base, where there are a few tooth-like projections on the lateral ridges. Bundles bridged.

Cross-section of No. 36.

37.—*Athyrium thelypteroides* (p. 163). Stalk green, pubescent; grooved in front and slightly on sides, except the lower half of the stipe. Stipe with tooth-like projections on the lateral ridges at the extreme base. Bundles as in No. 36.

38.—*Onoclea sensibilis* (p. 265). Stalk yellowish (often pinkish at base), smooth, triangular in large specimens, with traces of grooves in front and on sides, above; 2-ridged below on sides; above, with two light lines that run into the broad wings of the rachis. Veins areolate.

39.—*Struthiopteris Germanica* (p. 269). Stalk dark green, deeply grooved in front, much flattened and with traces of grooves on sides. Rachis very narrowly winged on each side of the front groove, so that it has apparently three grooves in front and two on each side. Some stipes have tooth-like projections at the base, which is more or less rhombic in cross-section. Bundles bridged, nearly 4×1.

40.—*Scolopendrium vulgare* (p. 174). Stipe scaly, somewhat flattened on three sides and 2-ridged above; traces of grooves in front near

the middle. Bundles very much curved and finally forming an X.

C. THREE BUNDLES.

I. Bundles Curved, arranged in a Ring.

See Nos. 5, 46–51.

II. Bundles Round or Oval.

41.—*Polypodium incanum* (p. 83). Stalk and under side of pinnæ covered with peltate scales with dark centers, and ovate, laciniate scales (especially on the front of stipe). Stipe articulated to rhizome; 2-ridged in front. Bundles three at extreme base, soon becoming two, and then one.

42.—*Polypodium vulgare* (p. 77). Stalk green, smooth or nearly so; 2-ridged so that the front often seems 2-grooved; articulated to rhizome. Bundles soon uniting as in No. 41.

Cross-section of No. 42.

43.—*Nephrodium fragrans* (p. 213). Stalk yellowish green, scaly and glandular-pubescent. Rachis and upper part of stipe grooved in front.

44.—*Ophioglossum vulgatum* (p. 341). Stipe green, soft, and spongy, grooved in front above. Bundles 3–6, obscure, arranged around the irregular spongy center. Veins areolate.

Small specimens of all the species belonging properly under D and E may occur here.

D. FOUR BUNDLES.

I. Bundles Round or Oval.

45.—*Polystichum Braunii* (p. 254). Stalk densely clothed with large scales and hairs. Stipe very short, flat in front; marked with curved scars when the scales are rubbed off; above, with traces of lateral grooves that run into two ridges below. Rachis grooved in front, flat on sides. Bundles four near base, often five above.

Small specimens belonging properly under E may occur here. See also No. 44.

II. Bundles Curved and arranged in a Ring.

* Bud completely enclosed in base of stipe.

46.—*Botrychium matricariæfolium* (p. 322). Stalk soft, whitish below, shading to pinkish (or brownish), and then green, above; spongy. Two lateral ridges and a slight groove extend a short distance below the base of the sterile segment. Two bundles at base, two to six (usually four) a short distance above. The succeeding species have similar stalks.

47.—*Botrychium lanceolatum* (p. 320) and

48.—*Botrychium tenebrosum* (p. 326) belong here, and probably also

49.—*Botrychium Lunaria* (p. 315) and

50.—*Botrychium simplex* (p. 319). The stems of these four species are too much like those of No. 46 to afford a means of distinguishing them from one another. Full descriptions are given on pages 315 to 326. *B. Lunaria* and *B. simplex* could not be obtained in a suitable condition for the study of the stalks.

Cross-sections of No. 46.

** Bud cavity at base of stipe open at one side.

51.—*Botrychium Virginianum* (p. 337). Stalk fleshy, pinkish. Divisions of rachis with wings that run into two ridges on the stipe just below the sterile segment. Bud pilose. Bundles as in No. 46.

See also No. 5.

E. FIVE BUNDLES.

I. Middle Bundle no larger than the two adjacent ones.

See Nos. 43, 44, 45.

52.—*Polystichum acrostichoides* (p. 244). Stalk brown at base, green above; more or less chaffy. Rachis and upper part of stipe slightly grooved in front; sometimes with traces of lateral grooves in large specimens. Lower part of stipe slightly flattened in front and with slight ridges (or only light lines) on sides.

Cross-section of No. 52.

II. Middle Bundle larger than adjacent ones.

(Nos. 53 to 57 have bundles as in No. 55.)

53.—*Nephrodium spinulosum* and *varieties* (p. 214). Stalk with scattered scales; 3-grooved to base, where it is slightly ridged on sides.

54.—*Nephrodium Boottii* (p. 221). Stalk with scattered scales; grooved in front, and slightly on sides nearly to base. Extreme base ridged on sides and grooved in front.

55.—*Nephrodium cristatum* (p. 224). Stalk with scattered scales; 3-grooved nearly to base, where it is ridged on sides. The front groove becomes obscure toward the base.

Cross-section of No. 55.

56.—*Nephrodium cristatum* × *marginale* (p. 242). Grooves, etc., as in No. 55. Rootstock with crown central as in No. 57 (not growing beyond the fronds as in No. 55).

57.—*Nephrodium marginale* (p. 236). Stalk densely scaly below; grooved in front to base and on sides. The lateral grooves run into two slight ridges at the extreme base.

Small specimens of Nos. 58 *and* 59 *may occur here. See also Nos.* 44, *and* 46 *to* 51.

F. MORE THAN FIVE BUNDLES.

I. Bundles regularly arranged.

Large specimens of Nos. 44, *and* 46 *to* 57, *may occur here.*

58.—*Nephrodium Goldieanum* (p. 230). Stalk with linear scales, and very large, dark-brown, lanceolate ones with paler margins. Rachis and upper part of stipe grooved in front, and with two light-green lateral lines that run into slight ridges at the base. Bundles usually seven, roundish.

Cross-section of No. 58.

59.—*Woodwardia Virginica* (p. 121). Stipe and lower part of rachis brown. Stalk grooved in front to base, and with two lateral lines running nearly to base. Rachis with a slight ridge below the base of each pinna; 5-grooved above, below 3-grooved, as is the upper part of stipe. Bundles usually 7 to 9, arranged nearly as in No. 58. Central tissue of

lower part of stipe usually dark brown and spongy. Veins forming a single row of areoles along the midribs of pinnæ and lobes.

II. Bundles irregularly arranged.

60.—*Pteris aquilina* (p. 93). Stalk brownish, with a dense sheath of hairs below ground, just above rhizome. Stipe flattened, and with one or two grooves in front. Primary and secondary rachises 3-grooved. Stems with light lines along sides. Bundles curved, flat, or oval, rather irregularly arranged.

Cross-section of No. 60.

FERNS OF THE POLYPODY FAMILY

IN this and the three following chapters is given a brief technical description of each of our ferns to supplement the key, and additional information that seemed sufficiently interesting to merit introduction. Those who use Gray's "Manual" or Britton's "Manual" will notice a number of changes in the scientific nomenclature. For the convenience of all such botanists the names used in these two works, when different from what we have adopted, are given in parenthesis with the letter G or B prefixed to indicate the particular book. This is not the place to give the reasons for adopting the present nomenclature, which is nearly the same as that used in Mr. B. D. Gilbert's "Check-list of North American Pteridophytes." The numbers following the names of the ferns indicate their position in the analytical key based on the stalks.

Common Polypody. 42.

Polypodium vulgare.

Fronds oblong, smooth, pinnate or deeply pinnatifid, four to ten inches high, rather leathery in texture.

"The forest floor is covered with a thick coat of moist brown leaves, but what is that perennial and springlike verdure that clothes the rocks, of small green plumes pointing various ways? It is the cheerful community of the poly-

The Common Polypody.

Page 78.

pody. It survives at least as the type of vegetation to remind us of the spring that shall not fail."—THOREAU.

HIS is one of the commonest and most widespread ferns in the world, probably on account of its hardy nature and not because its spores are more numerous than those of other ferns. It can flourish under the most adverse conditions, but prefers the top of a shaded ledge of rocks. In such a situation it spreads rapidly by means of its much branched rootstock, which has given it the name polypody, or "many feet." When there is too little room for its roots the polypody is stunted in its growth, but it usually manages to collect enough leaves and twigs upon its own private ledge to form by their decay the rich black earth in which it thrives.

On account of its thick, leathery texture it seems especially fitted to survive long periods of dry weather. The evaporation of moisture from the frond is greatly retarded by the thick cuticle, or layer formed by the outer walls of the surface cells. Even in midsummer the fronds are fresh and green, but if the rains delay their coming too long, they curl up as if they were dying. Yet a good shower is all that is needed to revive them. Like other plants that grow in dry, exposed situations, the polypody responds readily to every drop of moisture and makes the most of it.

In winter the fronds curl up in much the same way, though this depends very largely on the severity of the

Common Polypody. (Reduced.)

Page 80.

weather. One winter that we recall was so mild for some weeks that the plants looked as fresh as in the most favorable summer weather. It may be that the cold is only the indirect cause of the curling, and that the fronds dry up because the ground is frozen. This might be determined by arranging some plants in such a way that the earth would not freeze, but at the same time the fronds would be exposed to the cold. The lower surface of the fronds becomes loosened and shriveled. When warmer weather comes most of these fronds freshen up and stay green until summer. On one occasion some fronds of the previous year were collected as late as the thirtieth of August. They were becoming spotted with brown, however, and would soon have fallen away from the rootstock, leaving a distinct scar like a small "Solomon's seal." In thus having its stipes "articulated" to the rootstock, the polypody differs from most of our ferns. The thickening at the end of the stipe is easily seen in the illustration.

The young fronds appear in the spring, and the large yellow sori are quite conspicuous by the middle of July. The illustration on page 40 shows the fruit-dots enlarged.

The common polypody is not ordinarily a variable fern, but a few forms differing from the typical one have been described. Of these the most distinct is the variety *Cambricum*, which has broad fronds and deeply pinnatifid pinnæ. It is not common, but should be looked for throughout the range of the species. The illustration is from a frond collected by Miss Mary F. Miller in the Catskills.

The Polypody at the Base of a Tree.

Page 82.

P. vulgare acuminatum is a form with acute or long taper-pointed pinnæ, very irregular in length, also irregularly but not deeply crenate, and thinner in texture than the ordinary form; the lowest pair of pinnæ completely separated from the others and bent in so as to touch each other on the face. It has been found only at Ilion, New York.

P. vulgare deceptum is a form from West Virginia with pinnæ once or twice their width apart, tapering from the middle to a somewhat acute apex. Tip of the frond long acuminate, crenulate, dentate, then serrate as it gives rise to the pinnæ.

Polypodium vulgare Cambricum.
(Reduced.)

Hoary Polypody; Gray Polypody. 41.

Polypodium incanum.

(B. *P. polypodioides.*)

Fronds oblong, two to seven inches long, pinnate or deeply pinnatifid, grayish, covered on the under side with peltate scales having dark centers. Sori small, near the margin.

IN Florida and the neighboring states the hoary polypody grows upon trees, and is rarely seen on rocks; but as it travels northward its habits change, and by the time it has reached Virginia

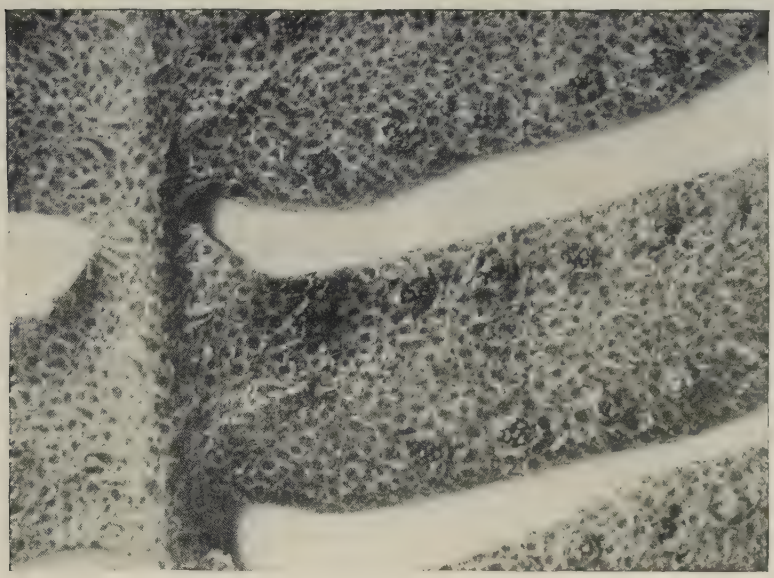
the rocks seem to be its only home. Very recently the fern has been found on the Maryland shore of the Potomac by W. P. Hay. This station is farther north than any other known.

Hoary Polypody.

The gray polypody is even better protected against drought than its near relative, for it is leathery in texture, and has besides a dense covering of scales which retard the escape of moisture. They are on the under side of the frond, where practically all the breathing-pores (*stomata*) are. Like the common polypody it has the habit of curling up when very dry, but it soon revives when moistened. It is one of the many "resurrection plants."

The sori are quite small, and inconspicuous in their setting of brown scales, which are sometimes so crowded together around the spore-cases as to appear like a cup-shaped indusium. The sori are near the margin. In herbarium specimens the edges are curled over so that the

sori apparently project a little beyond them. The illustrations in certain books were evidently drawn from dried



Sori and Scales of the Hoary Polypody. ×5½.

specimens. The sori should appear as shown on the frond above.

Powdery Cloak-fern.

Notholæna dealbata.

Fronds triangular-ovate, two to six inches long, acute, broadest at the base, tripinnate. Pinnæ ovate, the lower slender-stalked; segments ovate or obovate, obtuse, lobed, crenate or entire, very small, white and powdery on the under surface. Stalks wiry, shining, dark brown.

WHEN the hairy lip-fern is spoken of we shall see that one of the devices adopted by ferns and other plants as a means of protection against dry weather is a hairy covering that keeps a layer of

moist air next to the surface of the leaf. Some plants, such as cacti, greatly reduce their surface and in this way diminish evaporation. A thickening of the epidermis, or outer layer of the leaf, serves the same purpose in other plants. In the arid regions of the Southwest there are several ferns that have a peculiar waxy coating on the fronds that seems to be a means of protection. All of them grow in exposed situations, and almost any one of them might well be called a "resurrection plant," for they shrivel up or flourish according to the weather. The exact chemical nature of this substance has never been determined, but it is apparently some sort of wax. It is readily soluble in alcohol, and one should be careful not to poison herbarium specimens with corrosive sublimate dissolved in strong alcohol, for the coating will probably be destroyed.

Powdery Cloak-fern. (Slightly reduced.)

The name "cloak-fern," which is derived from the scientific one meaning "spurious cloak," refers to the incomplete or rudimentary indusia over the sori.

Maidenhair.

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The powdery cloak-fern is found from Nebraska and Missouri to Arizona and New Mexico.

The illustration is from a specimen in the herbarium of Capt. J. Donnell Smith.

Maidenhair. 4.

Adiantum pedatum.

Frond forked into two equal, recurved branches which bear several pinnæ on one side. Pinnæ with thin, oblong or triangular-oblong pinnules. Veins springing from the lower, entire margin.

EVERY ONE knows the name "maidenhair," but it is often incorrectly applied to other ferns, particularly the ebony spleenwort, which also has dark stems. In fact there seems to be a notion that any small fern is a "maidenhair." Yet if the fern has once been pointed out, there is little excuse for again mistaking any other fern for it, although very small fronds of the maidenhair itself are puzzling at times. For the first year or two the fronds are like single pinnæ of the mature plants. Later there appear two shorter pinnæ in place of the lowest pair of pinnules, and finally the fronds acquire their usual form.

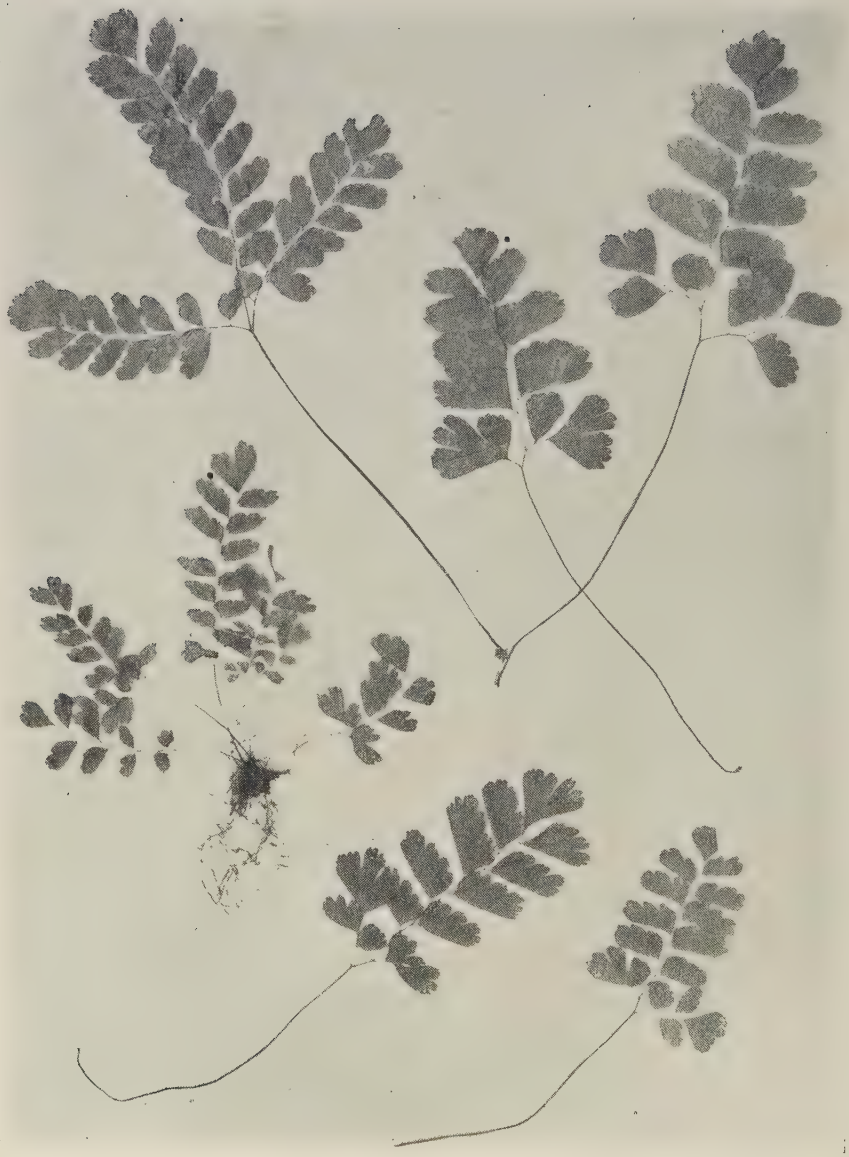
Another common error is to call the common meadow-rue maidenhair, probably because of the resemblance in shape of its leaflets and those of the maidenhair-ferns common in greenhouses. One glance at the pale stems will show that the plant is not the fern in question. They are not only green, instead of polished, dark brown, but they branch in an entirely different manner.

The name *Adiantum* is derived from a Greek word meaning "unwetted," because rain and dew roll off without wetting the pinnules. Strong alcohol readily wets them, and if they are then thoroughly rinsed in water, the latter also adheres to them. So it would seem that the

Maidenhair.

proverbial duck's back and the maidenhair are alike in one respect: they turn water by reason of an oily or waxy coating.

The maidenhair is to be looked for in all rich woods, but it is seen in greatest perfection in little dells in rocky



Young Maidenhair.

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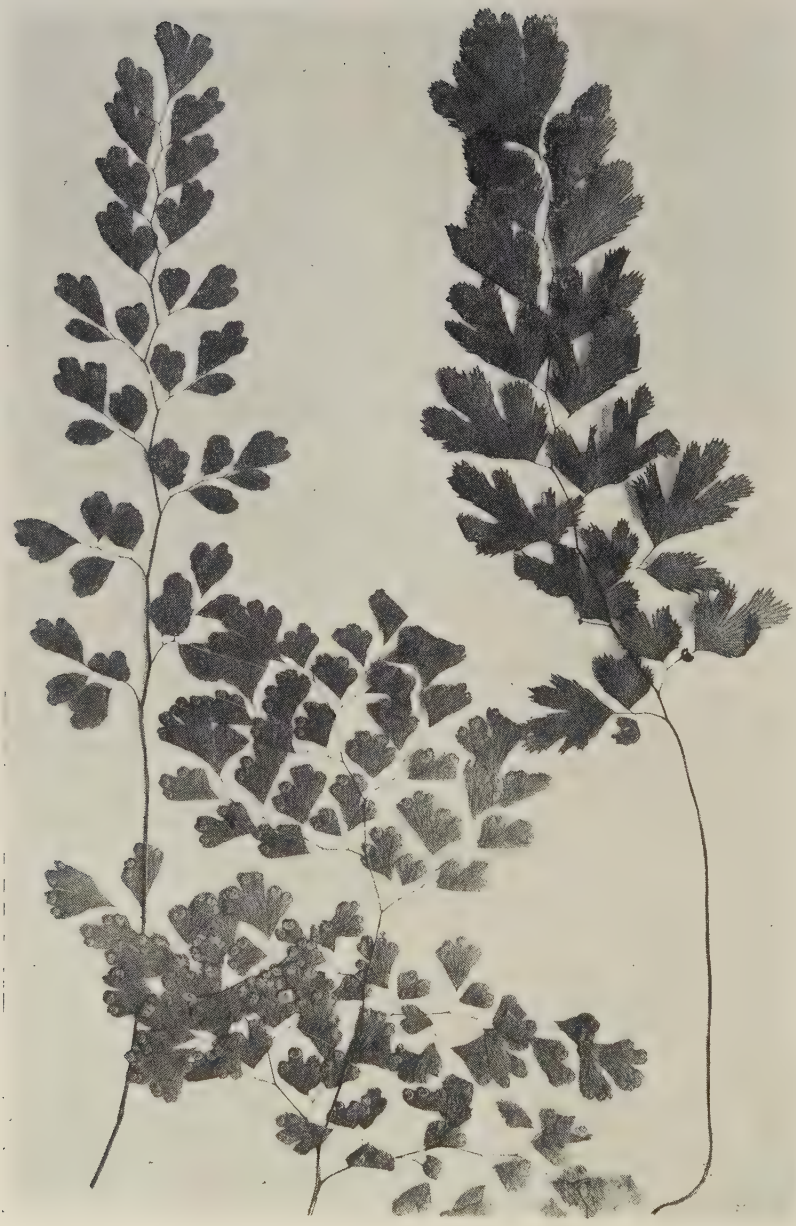
woods where the soil from the surrounding slopes is gradually washed down. In the black earth it luxuriates and often sends up fronds with a spread of fifteen inches or more at the top of a two-foot stipe. But such plants are the exception, and they are usually but half as large. Sometimes it ventures to the edge of a cliff, but it has a precarious footing, and never seems at home like the true rock-dwellers. It cannot be the sunlight that has a bad effect upon it, but rather the lack of moisture and sufficient soil. We have in mind a row of fine large plants skirting the edge of a cornfield at the foot of a steep, sunny slope, where they grow luxuriantly. The only effect of the sun seems to be that they have, even when mature, the reddish tint seen in the uncoiling fronds.

The rootstock creeps along near the surface, and as it forks frequently, quite a clump of plants may be formed in a few years.

When the young fronds appear, they wear all shades of pale green and red, while the stems vary from red and purplish to brown. At first they have a decided "bloom," but are afterwards highly polished dark brown. The second illustration gives an idea of the way the fronds uncoil.

An illustration showing the enlarged sori is given on page 41.

In Europe the true maidenhair or Venus'-hair is quite abundant, but in this country it is confined to the South. It occurs in Virginia, and has been found north of that state in only one place—near a stream flowing from hot springs in South Dakota. It has also been reported from



Venus'-hair.

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southern New York, but according to L. M. Underwood the discovery "was based on a want of knowledge of the young stages" of the common maidenhair, which are so different from the mature fronds. It is certainly not common in Virginia, for several summers spent in the mountains of that state, and even a stay of three months in a region where it was known to occur, failed to bring it to light.

This species might be called the true maidenhair, for the name was first applied to it in Europe, and then transferred to our common fern. It is a matter of doubt whether the name was given on account of its slender black stems or because of its fine, black, fibrous roots.

As shown in the illustration, it differs from our common maidenhair in having a continuous main rachis and wedge-shaped or rhomboid pinnules. The veins spread from the base like the ribs of a fan, instead of springing from the lower margin as in *A. pedatum*.

Brake; Bracken. 60.

Pteris aquilina.

(B. *Pteridium aquilinum.*)

Fronds ternate at the summit of an erect stalk; the widely spreading branches twice pinnate; the lower pinnules more or less pinnatifid.

"The heath this night must be my bed,
The bracken curtain for my head."—Scott.

HE brake always comes to mind as the typical cosmopolitan fern. There is no other one so widely distributed and in such abundance, and it has lent its name to many a large, coarse

The Bracken. (Much reduced.)

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species to which it is in no way related. It is a hardy, aggressive fern that spreads by spores and by a long, creeping rootstock that may grow ten or even twenty feet in a season. Fortunately for the farmer, it is at home in sandy woods and thickets, and does not seem to care for cultivated fields. We have seen a row of it at the edge of a woodland stopped abruptly by the plowed ground, except for a few scattered outposts among the corn. The rootstock branches frequently, and is so rapid in its growth that when the fern has become established it soon forms dense thickets. The numerous fronds are wide-spreading at the summit of the stout, hard stipes. The latter may be two feet or more tall, and the frond is often two or three feet wide.

The name *Pteris* is from a Greek word meaning a wing, and as the fern is so widely spread and so abundant, the brake has come to be regarded as the typical fern. The ferns proper are known as *Filices*, from the Latin *filix*, a fern, but the name applied by botanists to the great group of plants that includes the ferns, horsetails, ground-pines, and a few others is *Pteridophyta*, literally "fern-plants." Why this fern should have been called the eagle-fern, and given the specific name *aquilina*, is not certainly known. A cross-section of the stalk with its numerous fibrovascular bundles shows a spread eagle, or "King Charles in the oak," or the print of the devil's hoof, as we please. Perhaps the old idea of the wing that gave us *Pteris* also suggested the specific name. It is like a large wing, hence an eagle's wing, just as coarse, rough plants often have the

prefix "horse." We have horse-mint, horse-nettle, horse-radish and many more.

The origin of the names found in tales of folk-lore is an unsafe subject for speculation, for they may date back so far that it is no longer possible to tell when or how they arose. Their charm lies in their very antiquity, and the plants of a new world, attractive as they may be, have always an air of incompleteness to one who reads history in nature's names. Not one of our native ferns, as far as we are aware, is known by an Indian name, though we must believe that they were not unnoticed by the red men.

The brake has been used for thatch, and farmers occasionally cut it as bedding for stock. It is also said that certain tribes of savages boil the rootstocks for food, so that this is one of the few ferns having any economic value.

The very young plants have bipinnate fronds that give no hint of their later ternate character. The mature plants exhibit considerable variation in the shape and cutting of the pinnules, as can be seen from the illustration on the opposite page. The two marked *a* are from sterile fronds growing in low, damp woods. Those marked *b* belong to the variety *pseudocaudata* of W. N. Clute, who has made a thorough study of this species. The variety is to be looked for near the coast from New Jersey southwards. The sandy, barren woods of the South, where the scrub-oaks and chinquapins contest with scrub-pines for the possession of the soil, are its favorite home. The extreme forms are well marked, but it passes insensibly over into the typical form which is found with it.

Some Pinnules of the Bracken. $\times\frac{1}{2}$.

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As shown in the two illustrations on pages 42 and 43 the marginal line of sporangia is at first completely hidden by the indusium, which is formed of the reflexed edges of the lobes. This is soon pushed back by the spore-cases as they develop. An illustration of a portion of a pinna showing apospory is shown on page 35.

On the stalks, near the axils of the pinnæ, there are little oval areas easily discernible. It has been found that when the stalks are young, these "nectaries" secrete drops of a sweet liquid, although the part it plays is not known. Flowers secrete nectar in order to attract insects that are instrumental in effecting cross-fertilization, but that is out of the question here.

Alabama Lip-fern.

Cheilanthes Alabamensis.

Fronds four to sixteen inches long, lanceolate, bipinnate, with numerous ovate-lanceolate, acuminate pinnæ. Pinnules triangular-oblong, somewhat acute, often auriculate, lobed, or incised. Stipes black, slender, wiry, clothed at the base with rusty wool.

HE Alabama lip-fern and the other two species found near the southwestern corner of our limits are not seen in herbaria as often as the hairy lip-fern. This is not due altogether to their rarity, but is probably owing to the small number of botanists in that section. This species is found from Virginia to Alabama, and west to Illinois, Tennessee, Arkansas, Texas, and Arizona.

All of our lip-ferns are rock-loving species. In the Southwest there are many more of them, and it is a difficult matter, even for an experienced student, to distin-

Alabama Lip-fern.

Page 99.

guish between them in some cases. With our four this is not hard, and the one here described may readily be told from the others by its smooth pinnæ.

The generic name *Cheilanthes* is derived from two Greek words meaning "lip" and "flower," in allusion to the shape of the indusia. The enlarged sori are shown on page 44.

The illustrations are from a specimen in the herbarium of Capt. John Donnell Smith.

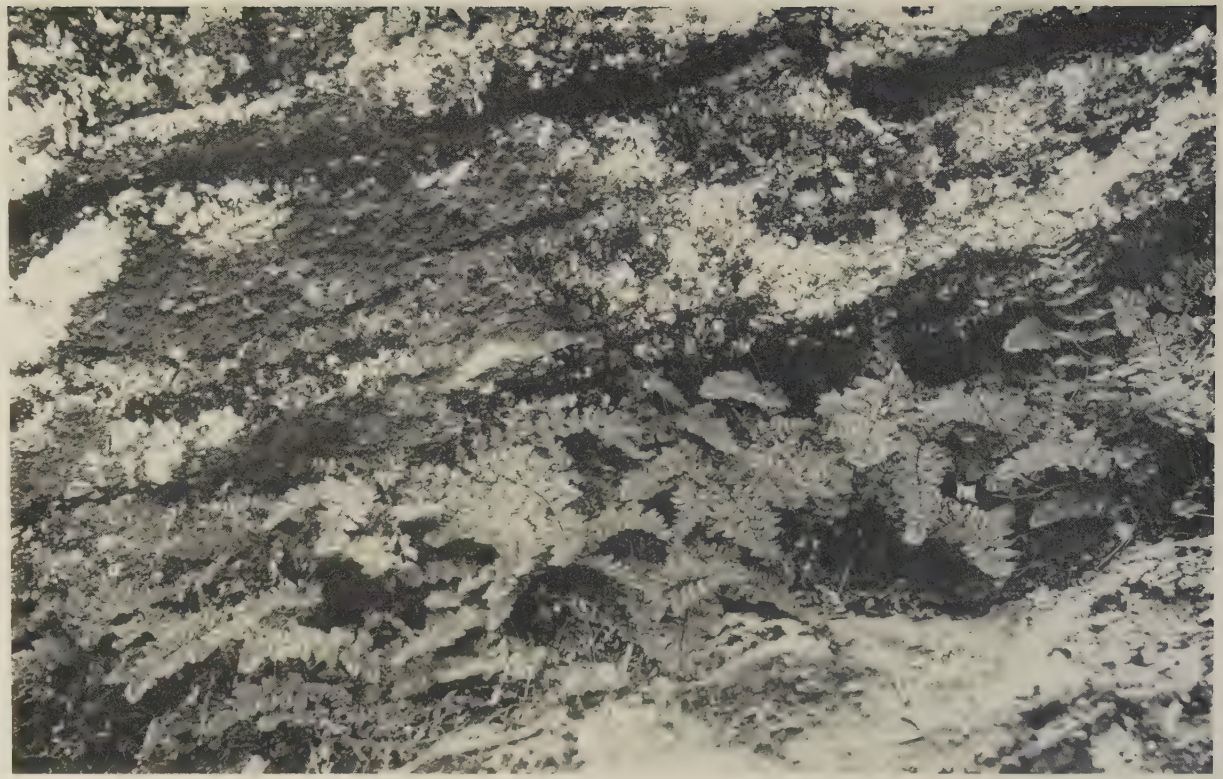
Hairy Lip-fern.

Cheilanthes vestita. 21.

(B. *C. lanosa.*)

Fronds six to fifteen inches tall, lanceolate-oblong, hairy, twice pinnate. Pinnæ usually distant; triangular-ovate. Pinnules oblong, crowded, more or less incised.

ONE cold January day twelve years ago, a party of us took a long tramp to a rugged hill where one of the number had, some days before, seen a new fern on the rocks. We searched a long time in vain, but at almost the last minute came across some disreputable-looking dead fronds springing from cracks in the rocks. It did not take us long to guess that we had found the hairy lip-fern at last. Every one who has made such a "find" can imagine with what impatience we awaited



Hairy Lip-fern.

Page 101.

the return of summer when we could see them fresh and green. Ever since that day this fern has been on our list of favorites, and the sight of it always brings back a part, at least, of that old thrill of pleasure.

It so happened that late in June, on our next visit to the hill, we came across a new lot of the fern in a little shaded pocket of rich earth near the base of an overhanging cliff. They were much larger than the ones first seen, and were all sterile, but this did not seem strange at the time, for we did not know that it might have been found elsewhere in fruit a month earlier. So another trip was planned for October, but still no spore-cases were on any of these ferns, while the stunted ones on the rocks, which we had not been able to find in June, where the full force of the southern and western sun beat upon them, were now heavily fruited. An incorrect explanation suggested itself. Gardeners know that some plants will "run to leaves" if planted in soil too rich for them, and it seemed probable that the ferns were behaving in the same way. Their growth was too luxuriant for fertility, we thought. So three plants were taken from the exposed rocks early the next spring, and were planted with the sterile ones in the pocket of earth, and carefully marked. In midsummer they were found to have longer fronds, but not a spore-case was found on one of them in spite of a careful examination with a lens. The evidence seemed conclusive, until a third lot of the plants was found in an even more abundant supply of soil. These were the finest we have ever

Hairy Lip-fern. (Reduced.)

seen, many of them being twelve or fifteen inches tall. Every year they are heavily fruited, so it seems certain that something else caused the sterility of the plants we have mentioned. But the last, heavily fruited ones grow in the full sunlight, just as those on the exposed rocks do, and we have since noticed that the fern prefers the most exposed situations. We almost hesitate to write it, for it all works out too smoothly to sound true, but a wind-storm blew down a large number of trees on the hill, and the plants that were once so well shaded now receive more sunlight, and they bear sporangia. After all, then, the amount of sunlight falling on the ferns is of more importance than the richness of the soil, if we can form an opinion from this evidence.

In dry weather the fronds curl up and are apparently dead, but they soon revive after a shower. Many of the other species of *Cheilanthes* grow on rocks, and they have adopted much the same means of protection against drought. The scales and hairs found on so many of them hinder the evaporation of water from the plant by holding a layer of more or less saturated air near the surface of the frond. If one has ever noticed how slowly a puff of smoke escapes from one of the bag-like spider-webs so common on bushes, it will not seem so strange that the hairs on the fern can retain a layer of moist air. In our species, as in many others, most of the hairs are on the under surface where the breathing-pores are so numerous.

As we shall see later, the small ferns that grow in tufts closely appressed to the rock on which they are found do not

reach out towards the window when they are planted in a glass fernery indoors. On the contrary, the fronds are so disposed that the brightest light must fall perpendicularly upon their upper surface. In order to accomplish this some of the fronds even bend back from the window. The lip-fern does not often grow in such tufts, but is usually seen in the rich soil collected on some narrow ledge or in a deep

Sori of *Cheilanthes vestita*. ×5½.

crevice. As we should expect, in the fernery it stretches toward the window. One plant under observation was not more than ten inches from the window, but the fronds as they appeared bent over to the light, and in one case the pinnæ were close against the glass.

The hairy lip-fern has been found in one or two stations in Connecticut, in New York, and thence to Kansas and Georgia.

Slender Lip-fern ; Fée's Lip-fern.

Cheilanthes lanuginosa.

(B. *C. Féei.*)

Fronds three to eight inches long, ovate-lanceolate, bi- to tripinnate. Upper pinnæ oblong-ovate, the lower ones deltoid, the lowest distant, the others contiguous. Pinnules minute, crowded, the terminal one a little the largest. Upper surface slightly woolly, the lower densely matted with whitish-brown, distinctly jointed, flattened, woolly hairs. Stalks densely tufted, at first hairy, dark brown.

Pinnæ of *Cheilanthes lanuginosa.* ×2

THIS lip-fern, which is our smallest species of *Cheilanthes*, is found in quite as exposed situations as any of the others. It occurs from Illinois and Minnesota to British Columbia, and south to Texas, New Mexico, and Arizona.

Fée's Lip-fern.

Page 107.

This and the woolly lip-fern belong to a different section of the genus from the two preceding species. The latter have flat segments, and the indusia are not, as a rule, continuous around their margins. The segments of the former are small and bead-like, and the indusia generally form a continuous rim around the edge of the segment. Besides, the fronds are more finely divided than in the other two species. The slender lip-fern can be told from the woolly one by its outline, its narrower indusia, and the size of the terminal segments of the pinnæ.

The illustration is from a specimen in the herbarium of Capt. J. Donnell Smith.

Woolly Lip-fern.

Cheilanthes tomentosa.

Fronds eight to twenty inches long, oblong-lanceolate, tripinnate. Pinnæ and pinnules ovate-oblong or oblong-lanceolate, densely woolly, especially beneath, with slender, brownish-white, obscurely jointed hairs. The terminal segments twice as large as the others, or nearly so. Indusium pale, membranous. Stipes stout, densely woolly, dark brown.

HE office of the protective covering of hairs on the hairy lip-fern has been explained. The woolly lip-fern is even more carefully guarded, for it is very much more thickly clothed with hairs, and even the stems are densely woolly. As we should expect, it is found in the most exposed situations on dry rocks.

What has been said about the differences between the slender lip-fern and two preceding species need not be repeated here, and we have already shown how the slender

The Woolly Lip-fern.

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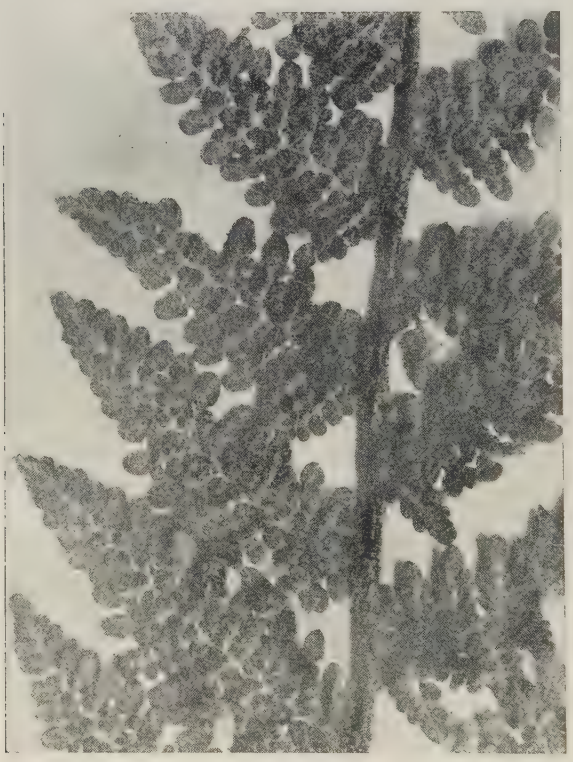
lip-fern may be told from this species. Both of them seem more at home in the arid Southwest, though the woolly lip-fern strays up as far north as Virginia, where it is found



Pinnæ of the Woolly Lip-fern. ×2.

sparingly. Its range is from Virginia to Georgia, and west to Missouri, Texas, and Arizona.

Slender Cliff-brake. 6.

Pellæa gracilis.

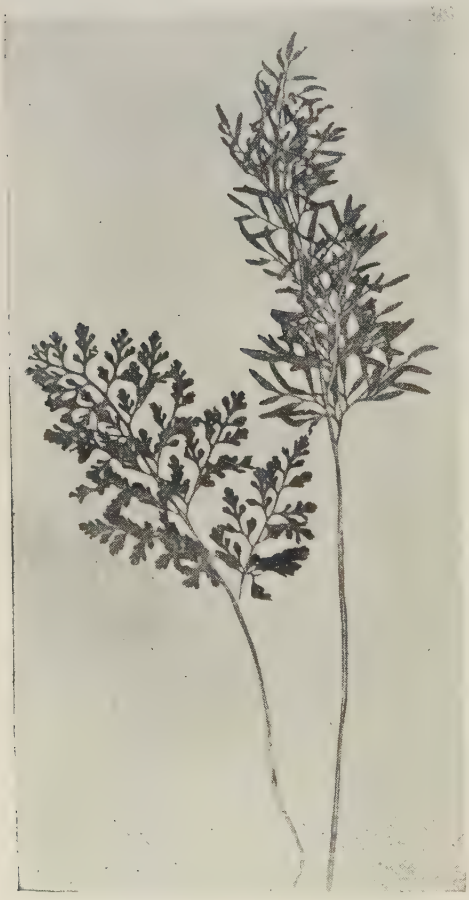
(B. *Cryptogramma Stelleri.*)

Fronds very thin, slender, with few pinnæ. The lower pinnæ once or twice pinnately parted into three to five divisions, those of the sterile frond ovate or obovate; those of the fertile frond oblong or linear-oblong. Three to six inches high.

Slender Cliff-brake. (Reduced.)

THIS might almost be called the filmy cliff-brake, it is so delicate and thin. It is the sort of fern one is apt to think of as growing in the damp shade of tropical forests, and yet it is one of the hardiest

ferns and is never found far to the south. Pennsylvania and Illinois and the mountains of Colorado seem to be the limits beyond which it cannot live. Limestone is the favorite resting-place of many rock-loving plants, but they will nearly all grow elsewhere. The slender cliff-brake seems to be more particular in its choice, and is never found except on limestone or calcareous shale. It is seen at its best in shaded ravines where it is constantly moistened by the spray from dripping water and shaded from the direct rays of the sun



Rock-brake. (Reduced.)

In the illustration the two fronds at the left are fertile. The upper one at the right is partly fertile, and the others sterile.

Closely allied to the slender cliff-brake is the parsley-fern, or rock-brake, which is found to the northward and westward from the northern shore of Lake Huron. It is known by several scientific names,

the one in most frequent use being *Cryptogramma acrostichoides*. In some books it is given as *Allosorus crispus*.

Some botanists place *Pellæa gracilis* in the genus *Cryptogramma* under the name *C. Stelleri*. The dividing line between this genus and the section of the genus Pellæa to which the slender cliff-brake belongs is not very well marked, but we need not concern ourselves with the technical points involved.

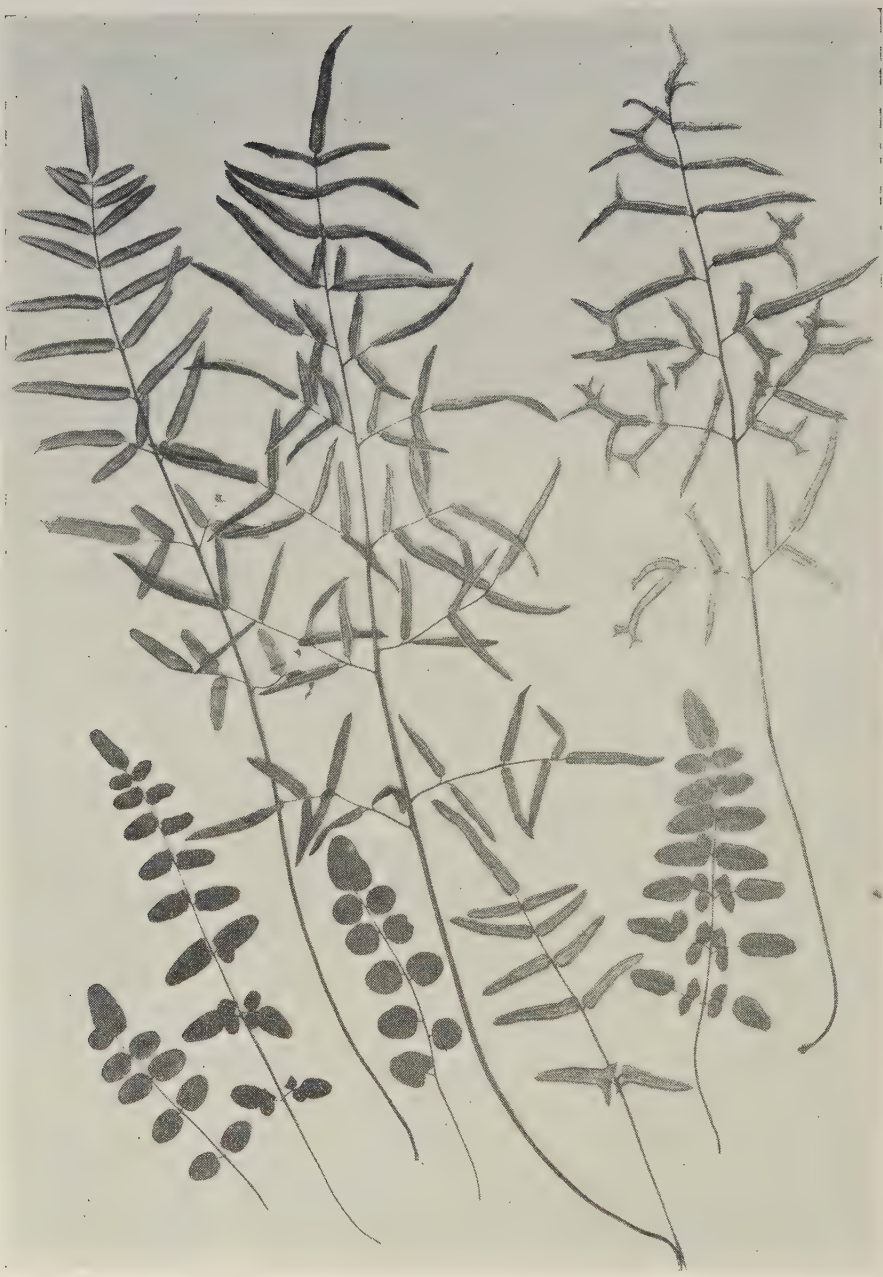
Purple Cliff-brake. 7.

Pellæa atropurpurea.

Fronds leathery, once pinnate. Lower pinnæ pinnate, or lobed, or entire. The divisions broadly linear or oblong, or those of the sterile frond oval; grayish green, pale below.

HIS is one of the ferns said to be "not common, but of wide range," and every one on seeing it for the first time must surely be delighted with its strange beauty. It seems so unusual for a plant even to live on the exposed rocky walls it seems to love, much less grow in such luxuriance. It is always a source of wonder that a fern can ever gain a foothold in such a situation, for in its youthful days, when the prothallus is growing, when the fertilization is effected, and the first delicate fronds develop, it seems so fragile and so dependent upon an abundant and regular supply of moisture. It may be strange to us, yet Nature has solved the problem, and we can usually find numerous young plants on the rocks where the fern is well established.

As a rule it prefers limestone, but it will grow on other



Purple Cliff-brake. (Reduced.)

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kinds of rock. We once saw a plant on a granite boulder, but it did not appear to be flourishing, probably on account of the very poor supply of moisture. The cliff-brake not infrequently becomes established on old walls, where it gets the lime it needs from the mortar. The most unusual situation we know of was in the crevices between the bricks of an old, disused iron-funace. It grew in abundance there and on a near-by stone wall, within a few feet of tide-water, and miles from any others of its kind.

The youngest fronds are tiny, roundish leaves, heart-shaped at the base, and so thin that they do not give a hint of their future leathery texture. The illustration of a series of fronds will show, better than words can tell, how they change from the simpler to more complex forms as the plant grows older. These little specimens hardly give more than a suggestion of the irregularity so common in the large fronds. No other fern we have grows so unsymmetrically. It often happens that two opposite pinnæ are quite unlike, and even the pinnules fork in unexpected places. The most extreme case of this we have ever seen is shown in the illustration on page 114. Counting every unusual lobe or forking, the large frond at the right has over thirty irregularities of growth.

The cliff-brake can withstand a great deal of cold weather, but in New England it is a "doubtful evergreen" according to George E. Davenport. Farther south the fronds last all winter and the pinnules do not drop off until late in the spring. The bare stalks last for a year or two before they finally decay or are broken off.

Young Fronds of the Purple Cliff brake. × $\frac{2}{3}$.

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Fronds of the purple cliff-brake may grow to a height of fifteen inches, though these would be considered very large. A peculiarity of the fern is that the sterile fronds are much less numerous than the fertile ones. Indeed, so great is the tendency toward spore-formation that they often begin to fruit when but an inch or two tall. The halberd-shaped frond near the middle of the illustration on page 116 and the small pinnate frond to the left of it are both fertile. All of the others are sterile except two in the upper right-hand corner.

On page 45 is given an illustration of a bit of a frond of this species showing the reflexed margin under which the spore-cases are hidden. Later this indusium is pushed back, and the edges of the pinnules are marked by brown lines of spore-cases.

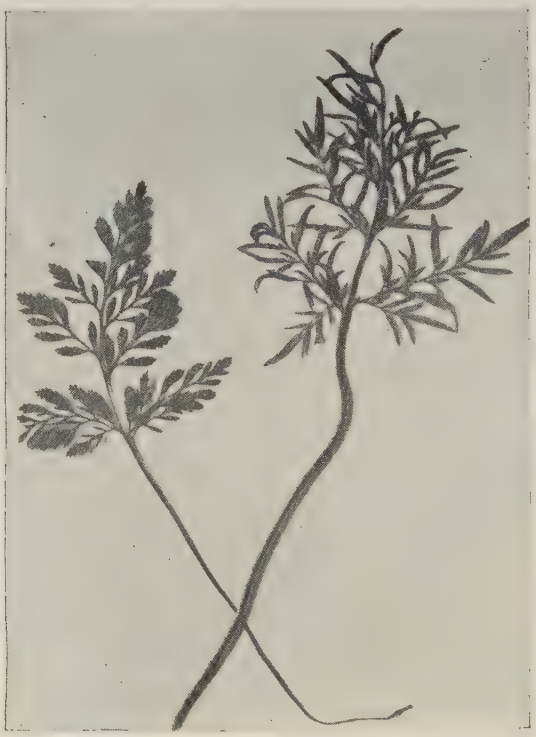
Dense Cliff-brake.

(*Pellæa densa.*)

Frond ovate or triangular-oblong, tripinnate with crowded, linear, sharp-pointed or mucronate segments. Usually fertile, with the margin entire and narrowly recurved. The rather scarce sterile fronds with sharply serrate segments. Stipes in dense tufts, slender, wiry, chestnut-brown.

HE dense cliff-brake is somewhat of a puzzle to students of plant distribution. It is usually regarded as a far western species, but within recent years it has been found in two eastern localities: on Mount Albert in Quebec, and in Grey County, Ontario. In the west it occurs from British Columbia and Washington to Montana, Wyoming, Utah, and

California. It would be interesting to learn in what way it was carried to those two eastern spots. It goes almost without saying that any plant found so far out of its usual range is not apt to be abundant.



Dense Cliff-brake. (Slightly reduced.)

The dense cliff-brake is a small species, being rarely more than six or eight inches in length, although large ones are occasionally seen that are a foot in length. It gets its name from its habit of growing in dense tufts, a common protective device of plants that are found in very dry situations. This fern springs from crevices in the

rocks. Like so many other rock-loving species, it produces spores in great abundance. As we have already seen, the purple cliff-brake begins to fruit when very small, and its fertile fronds are much more numerous than the sterile ones. The same seems to be true to an even greater extent of the dense cliff-brake, for its sterile fronds are said to be rare. Most rock-loving ferns have short, slender, creeping rootstocks that can insinuate themselves into the crevices in such a way as to hold on most securely and be best protected. It is out of the question for them to try to spread by means of the rootstock, or in any other way than by the spores. The walking-fern is an apparent exception, but it must have a mossy rock if it is to thrive. The bulbiferous bladder-fern has another interesting device, but it ought hardly be called a rock-fern, for it grows in places where it has an abundance of moisture and rich soil. The cliff-brakes, the lip-fern, the little spleenworts, and others must bear numerous spores if they are to get along in the struggle for existence. It is at best a difficult matter for any plant to reach maturity in the face of so much competition, and how much harder when all the conditions are apparently against the young sporeling! Their only hope lies in taking as many chances as possible, — in producing numerous spores.

Virginian Chain-fern. (Reduced.)

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Virginian Chain-fern. 59.

Woodwardia Virginica.

Fronds two to four feet tall, pinnate, with lanceolate, pinnatifid pinnæ. Segments oblong. Veins forming a single row of areoles along the midribs of the pinnæ and segments. Outer veins free.

N low woods and swamps near the coast one may be quite sure of finding this fern, which is one of our largest and handsomest species. Farther inland it is less common, but it should be looked for in company with Pogonia, and Calopogon, and other swamp-loving orchids. In such places it often forms dense clumps, for it is a vigorous grower, having a long, stout, creeping rootstock. A plant with fronds only ten inches high will have a rhizome as thick as a lead-pencil. In the woods it reaches a height of three feet or more, but it has a "drawn-out" appearance because the pinnæ are quite far apart. In sunny swamps the pinnæ are closer together, and the fronds are frequently four or even five feet tall.

A beginner is apt to pass it by, thinking it to be the cinnamon-fern, a very common species that grows in similar situations. Yet when the characteristics of the chain-fern are once fixed in the mind, and we have seen it growing once or twice, there is never any more trouble about it. The cinnamon-fern has straw-colored stems, and the pinnæ have free veins that fork once, or sometimes twice. The stipe of the chain-fern is dark brown, and the veins of the pinnæ form a single row of narrow meshes (areoles) along each side of the midribs of the pinnæ and lobes; then they

Virginian Chain-fern.

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run straight to the margins, forking seldom. Its fronds come up singly along the creeping rootstock, and they are somewhat glossy in appearance. The rather dull fronds of the cinnamon-fern are grouped in a circle. If there should still be any doubt, a glance at the cut end of the stipe will settle the question. In the stipe of the chain-fern there are about seven oval fibrovascular bundles, but the stalk of the cinnamon-fern has but a single curved one. On page 46 is an illustration of the sori of the Virginian chain-fern. The sporangia and indusia are attached to the veins that form the outer edges of the areoles. When young they are separate from one another, but close enough to remind one of the links of a chain. Occasionally a small sorus is found on one of the veins beyond the row of areoles, or in a secondary areole formed by the union of two veinlets from adjacent lobes, as shown in the illustration.

As they mature the spore-cases push back the indusia, and finally form brown lines parallel to the midribs. The fertile fronds are usually betrayed by a glance at their upper surface, which is more uneven than in the sterile fronds. The spores ripen early in July. One summer many second-growth fronds, with very young fruit-dots, were found on the first of August, while a month before the same clump of plants was searched in vain to find specimens young enough to show the indusia in good condition.

The Virginian chain-fern is to be looked for throughout our limits. It is not an evergreen in spite of its rather thick pinnæ, which are much hardier-looking than those of many of our evergreen species.

Narrow-leaved Chain-fern. 28.

Woodwardia angustifolia.

(B. *W. areolata.*)

Fronds deeply pinnatifid, with lanceolate, serrulate divisions united by a broad wing that becomes narrower below. Fertile fronds taller, with linear pinnæ connected by slight ridges on the rachis, or by narrow wings above. Veins areolate.

AT the first sight of the handsome, dark-green, glossy fronds of this fern one is apt to consider it a form of the common sensitive fern. Both species have sterile fronds somewhat alike in shape, both have much the same habit of growth, and they are found in similar situations. The resemblance extends even to the venation, for in both species the veins everywhere form irregular meshes or areoles (see page 355). A glance at the fertile fronds will set one right in an instant. The chain-fern bears its sori on the under side of long, narrow pinnæ. The spore-cases of the sensitive fern are shut up in little pods formed from the much contracted and rolled lobes (see page 52). If we are out early in the summer when only the sterile fronds are in sight, the fibrovascular bundles will set us right. Each species has two bundles in the stipe, those of the chain-fern being oval or nearly round, while those of the sensitive fern are flat and nearly three times as long as broad. Its frond is more triangular in outline, with the lobes more inclined to be pinnatifid, or with wavy margins. The frond of the chain-fern is about the same width at the base as in the

Narrow-leaved Chain-fern.

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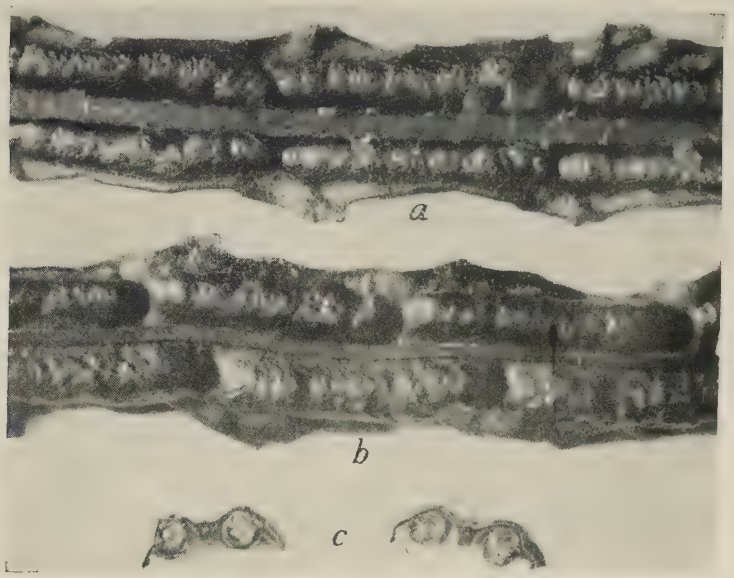
middle, and it is more glossy and firmer in texture, and the edges of the lobes are cut into fine teeth.

Narrow-leaved Chain-fern.

The chain-fern is stunted and pale when growing in the sun, and it is seen to perfection in dense woods, seem-

ing to prefer beds of sphagnum or light, rich soil. The first fronds appear quite late in the spring. They are smaller than those which come up later. A large plant has four or five sterile fronds, each a little taller than the preceding ones, until the largest is eighteen to twenty-four inches tall. A little farther along the slender, creeping rhizome the fertile fronds are produced late in June. A plant rarely has more than two in a season. They are somewhat taller than the sterile fronds, and have glossy, dark-brown stems.



Sori of Narrow-leaved Chain-fern. *a*, under surface, and *b*, upper surface of pinna; *c*, sections across sori. ×3½.

The sori are very large and are covered by thick, persistent indusia. The fruit-dots are sunk so deeply in the under side of the pinna that their outline is distinctly

visible from above. A section across a fruit-dot reveals the spore-cases enclosed in a tube formed of the indusium and the pinna.

In the narrow-leaved chain-fern we have an illustration of what also occurs in many other species. The sporangia are developed at the expense of the green tissue, so that the divisions of the fertile frond are much contracted. It is not unusual, however, to find incompletely fertile fronds, and careful search will bring to light a complete series from the typical fertile fronds to the ordinary sterile ones. Sometimes a few pinnæ, or one side of the frond, will be sterile and not nearly as much contracted as the other part. Perhaps the most curious case is where the plant has tried to produce a fertile frond, but has succeeded only in forming a tall sterile frond with a brown stem and long, narrow divisions nearly disconnected. This form of frond will sometimes have a straw-colored stem like that of the usual sterile one. The sensitive fern exhibits somewhat similar peculiarities in the variety *obtusilobata*, and for convenience in referring to the curious fronds of the chain-fern we are in the habit of calling them the "*obtusilobata* form," because no other botanist has ever seen fit to give them a name.

The fertile fronds grow very erect, like those of so many other ferns that are found in thickets and dense woods. They do this, probably, to be able to shed the spores as far as possible above the dense, lower vegetation, as well as to obtain the greatest amount of light from above. This makes it necessary for the pinnæ to twist horizontally in

order to receive the light upon their upper surfaces instead of the edges. At the tip of the frond the pinnæ are more or less grown together, and the whole end often bends

"Obtusilobata" Forms of *Woodwardia angustifolia*. (Reduced.)

over. This bending is sometimes carried to extremes, and both the pinnæ and tip of the frond curl over as shown in the illustration on page 126.

In spite of its thick, firm texture this fern is not an evergreen. The fertile fronds, however, remain erect until the following summer, and it is probable that most of the spores are shut in until then by the thick, firm indusia.

It is to be looked for throughout our limits.

Pinnatifid Spleenwort. 13.

Asplenium pinnatifidum.

Fronds two to eight inches long, lanceolate, pinnatifid, or pinnate below, tapering above into a slender prolongation. Lobes roundish-ovate, obtuse. The lowest pair sometimes long tapering.

HE little spleenworts that grow on rocks are among our daintiest and most interesting ferns. Their very hardihood in selecting the exposed situations in which they are found is sufficient to attract attention. The little pinnatifid spleenwort yields to none in endurance. What a surprise it was to find it on the exposed southern face of a nearly smooth rock at Harper's Ferry, still perfectly fresh although it had been in the blazing sun through the summer and fall! It is true that the plants were stunted, but they sprang from such tiny cracks in the nearly bare rock that it was almost impossible to conceive how they ever gained a foothold and survived their prothallus days. W. R. Maxon, who has collected it on the Virginia shore near Washington, says that it seems to prefer the deep crevices in which the fronds are partly hidden and protected. It then grows much taller than the Harper's Ferry plants, which are shown about two-thirds natural size at the bottom of the

illustration (*a*). The fern is never a large one. The limit is said to be ten inches, but most specimens are less than two-thirds as long.

The Pinnatifid Spleenwort. $\times\frac{2}{3}$.

This fern is quite variable in outline. Some fronds have two or three pairs of pinnæ below, and deeply cut lobes above, while the tip is only slightly prolonged.

Others which are merely lobed below and wavy-margined above have long, slender prolongations. These are not very unlike the walking-fern in general appearance, and they occasionally take root at the tip in the same manner. It can be distinguished by its free, forking veins from the walking-fern whose veins everywhere form irregular meshes. The books all state that the veins of the pinnatifid spleenwort never form meshes, but in several fronds we have found as many as four or five, exactly like those of the walking-fern, near the tip.

Like most of its small relatives this spleenwort fruits heavily. When young the sori are long and covered with an indusium as in the other species of *Asplenium*, but they soon run together and cover the under surface of the frond. Even the smallest frond of the young plant (*b*) bears a few sori.

Though it ranges from New York to Illinois and southward, the pinnatifid spleenwort is one of our rarest ferns. To give an illustration, the few little plants we stumbled upon at Harper's Ferry were the only ones found in fourteen years of fern-hunting in six states. It should be looked for wherever there are cliffs or rugged boulders.

Quite recently the supposed northern limit of this species has been extended to Connecticut by its discovery at Sharon in that state. It is not probable that it will be found any farther to the north. The small spleenworts seem much more at home in the South than they do in the colder New England states.

Scott's Spleenwort. 19.

Asplenium ebenoides.

Fronds three to nine inches long, lanceolate, pinnatifid, or pinnate below, the apex more or less prolonged and slender. Divisions lanceolate from a broad base.

N the chapter on Reproduction, the possibility of the formation of a natural hybrid, or cross between two species, was mentioned. This little fern, which has been known about half a century, presents such peculiarities that as early as 1862 it was suggested that it might be a cross between the walking-fern and the ebony spleenwort. This hypothesis was generally accepted until recently, when fern students became divided into two camps over this question. The fern has the slender prolongation, which occasionally takes root, of the walking-fern, and, near the tip, the same net-veins, while its pinnæ are like those of the ebony spleenwort in venation and general outline. The stems are also intermediate in character between those of the two parent species (see page 70). To strengthen the argument in favor of its hybridity, Scott's spleenwort occurs only in company with the other two species, and usually single plants, or only two or three at most, are found in any place. Besides, it appears strange that a true species should occur, one or two plants to a state, over such a wide range as Vermont, Connecticut, New York, Pennsylvania, New Jersey, Maryland, Virginia, Illinois, Indiana, Missouri, and Kentucky. It has been claimed, also, that the spores are usu-

Scott's Spleenwort. Slightly reduced.)
a, From Virginia; *b*, from Alabama; *c*, from Maryland.

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ally incapable of germinating, and this, as well as the great irregularity of its fronds, is taken as further evidence of its hybridity.

Those who think the fern is not a hybrid base their arguments chiefly on its occurrence in great abundance in a ravine in Alabama. It grows there very luxuriantly, and plants of all sizes from sporelings up to the largest can be found. This fertility is not what one would expect of a hybrid between two species in different genera.

The question is one which may be argued indefinitely, and two prominent botanists together who visited the glen in Alabama arrived at opposite conclusions. To Miss Margaret Slosson belongs the credit of having proved conclusively that Scott's spleenwort is a hybrid. After many unsuccessful attempts she obtained hybrids that are identical with some forms that have been found in nature. Through her courtesy we are able to give a photograph of some of the fronds she obtained. The method she adopted is described on page 34.

The fern is an evergreen. A plant found in Maryland the last week in June still retained the fronds of the year before, though they were beginning to turn brown. The new ones had not fully uncoiled, and the sori were quite young. The three fronds marked *c* on page 134 came from the same plant. They exhibit almost as wide a divergence of form as fronds from separate plants. The long slender one and two others like it were fertile. As seen from the illustration, none of the pinnæ has exactly the shape of those of the ebony spleenwort, but specimens are now and

Scott's Spleenwort. Miss Slosson's Hybrids. (Natural size.)

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then found in which they are exactly the same shape. Occasionally the pinnæ, as well as the tips of the fronds, are found rooting.

Green Spleenwort. 10.

Asplenium viride.

Fronds two to ten inches long, linear, pinnate, pale green. Stems green except at the base. Pinnæ thin, roundish-ovate or ovate-rhomboid with indistinct midveins.

Green Spleenwort. (Natural size.)

THIS dainty little fern is found scattered over northern Europe and America, but does not seem to be abundant anywhere. In the United States it grows only in the mountains of Vermont and

Maidenhair Spleenwort.

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in three or four of the northwestern states, but is found more abundantly north of our borders. It is to be looked for on shaded cliffs where the maidenhair spleenwort grows. These two species are much alike, though the more delicate texture and green stems of the green spleenwort make its identification easy. It is one of our smallest ferns, being rarely more than four or five inches high. We have seen specimens from Europe that are nine and one-half inches long.

Maidenhair Spleenwort. 9.

Asplenium Trichomanes.

Fronds three to eight inches long, linear, rather rigid. Pinnæ dark green, oval or roundish-oblong, entire or finely crenate; midvein forking.

F we are so fortunate as to live near woods where rugged cliffs or boulders are abundant, we will be almost certain to find this beautiful little fern in company with the polypody, the ebony spleenwort, and other rock-lovers. Even in midwinter its dark-green pinnæ and polished dark-brown stalks are to be seen springing from some deep crevice, or spreading in a dainty rosette upon the mossy surface. Perhaps, at this season, a part of its charm comes from the wintry surroundings, for a too critical observer will see that the fronds are rather ragged. The pinnæ are deciduous, and begin to drop off here and there quite early in the season, although most of them remain until the following spring. The bare stalks often last for two or three years, so that

Maidenhair Spleenwort.

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they may be more numerous than the living fronds. This is true especially of the plants growing back in the crevices, for they are soon broken from the more exposed plants.

The maidenhair spleenwort is to be looked for throughout our limits, especially where there are outcrops of limestone, which it evidently prefers, although it grows on all kinds of rocks. By beginners it is commonly mistaken for the ebony spleenwort which often grows with it. The latter is a larger fern, its pinnæ are not so roundish, and the midveins of the pinnæ extend almost to the tips, instead of branching and soon disappearing as in the smaller fern. The stipe of the ebony spleenwort is not ridged or flattened as in the maidenhair spleenwort.

Although not usually called a fragrant fern, the maidenhair spleenwort has a decided "woodsy" odor that is very pleasant. The same is also noticeable in the ebony and Bradley's spleenworts. Flowers depend largely upon their odor to attract the insects needed to effect their fertilization, but it is not clear why ferns should need any such device to attract insects, or what good their visitors would do. It may be that the odor which is so agreeable to our senses repels the tiny creatures that might eat the spores or injure the fronds. These three species are not often attacked, while others seem to be the favorite food of insects. A thorough study of this subject would be of interest and scientific value.

A writer in the "Botanical Gazette" has described certain curious movements made by this fern when brought from the shade into a bright light, especially near the

middle of the day. The fronds vibrate in a plane perpendicular to the plane of the pinnæ, with a motion "more rapid than the second hand of a watch, but with occasional stops in the course of each half-vibration." It is hard to imagine a cause for such movements.

A form of the maidenhair spleenwort with more or less deeply cut pinnæ has been called *incisum*. Similar fronds from California were for a long time believed to belong to the same variety, but are now classed as a separate species under another name.

Small Spleenwort. 17.

Asplenium resiliens.

(G. and B. *A. parvulum.*)

Fronds four to ten inches tall, narrowly linear, pinnate, rather rigid, erect. Pinnæ thickish, oblong, entire or finely crenate, auricled at the base. Mid-veins continuous.

ALTHOUGH we had been familiar with the small spleenwort from herbarium specimens, it was a great pleasure to see it in its haunts. While wheeling near Lexington, Virginia, a great bend of the river forced the road against the base of a steep hill, and there, close to every passer-by, we saw it. Though it is so prim and plain and unpretentious, there is a certain charm about it which makes it more attractive than many far more showy ferns. It has a neatness all its own.

The beginner who finds this fern for the first time is apt to think he has an unusual specimen of the ebony spleenwort. But the small spleenwort is stiffer and has

thick, blunt pinnæ which are only slightly auricled, and are usually opposite, and entire or nearly so. All the fronds

Small Spleenwort. (Reduced.)

are erect, and the stiff stalks are nearly or quite black. The pinnæ of the ebony spleenwort are, as a rule, alternate, and are serrate or incised. The pinnæ of both species are often bent downwards, this being especially true of the

small spleenwort, though it is not very noticeable in pressed specimens. A comparison of the stalks as described in the key will be of assistance in distinguishing the two species.

The small spleenwort is to be looked for especially on limestone, but botanists living north of the Potomac can hardly hope to find it, for its range extends from Virginia to Florida and westward. Perhaps the most northerly station for this species is in Alexandria Co., Virginia, where it was collected in 1884 by Wm. Palmer, who says the station is in sight of Washington.

For a long time this fern has been known as *Asplenium parvulum*, but it has been shown recently that the name *A. resiliens* should be used. This is much more appropriate, for there are many smaller spleenworts, and the stiff, "resilient" stems force themselves upon our attention when we attempt to spread out the fronds in mounting a pressed specimen.

Ebony Spleenwort. 18.

Asplenium ebeneum.

(B. *A. platyneuron.*)

Fronds six to eighteen inches tall, linear-oblanceolate, pinnate. Pinnæ oblong or oblong-linear, finely serrate or incised; auricled at the base.

IF on some cliff or in rocky woods we find a fern with a rosette of short fronds close to the ground and a cluster of much longer, erect, fertile ones springing from the center, we may feel safe in calling it the ebony spleenwort. Its graceful form, bright

Ebony Spleenwort. (Reduced.)

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color, and dark-brown, polished stems make it one of our most attractive ferns.

The habit of sending up its fertile fronds as far as possible while the less important sterile ones are close to the ground is common to several of our ferns. It seems to be due to the effort to scatter the spores as widely as possible. In this case we have the additional advantage that the evergreen sterile fronds are better protected during the winter so that they can be of use to the plant in the spring. The rootstock is very small and can store up little nourishment, but with green fronds to prepare food materials, the young fronds are able to get a good start at the approach of warm weather. Early in the year the fertile fronds begin to show white blotches, and then die, so that few of them remain green in the winter.

The pinnæ of the sterile fronds are close together, but those of the fertile ones are quite far apart and twisted more or less into a horizontal position so as to receive the greatest possible amount of light upon their upper surface. The wide spaces between the pinnæ prevent them from shading one another too much. This twisting and spacing is not necessary in the case of the sterile fronds, for they spread out horizontally. When ferns are grown in a glass case indoors they usually stretch out towards the light, and only a few of the rock-loving species bend backwards. This is very noticeable in the ebony spleenwort. The sterile fronds grow luxuriantly, but are pressed close to the earth, and creep in and out between the stems of the other ferns near them.

Ebony Spleenwort.

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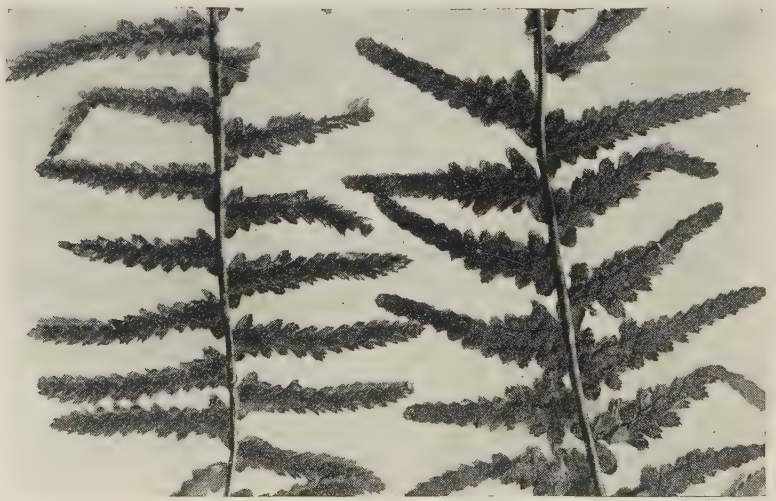
The ebony spleenwort rarely bears fruit-dots when grown indoors. As we have said, the sterile fronds behave like those of Bradley's spleenwort, page 153, but the fertile ones retain their erect habit. They are not so nearly vertical as the ones growing in the open, but bend over somewhat toward the window, while the pinnæ are twisted so as to let the light fall directly upon the upper surface. It is but another illustration of what will be mentioned so many times in these pages. A green plant must have light or die. Some botanist has pointed out that the leaves of a tree are practically but one layer in depth. Even those near the trunk on the lower branches are so placed that, at some time during the day, they receive direct



Asplenium ebeneum serratum. (Slightly enlarged.)

rays of light from an opening in the foliage above. If we recall the fact that the "chemical rays" of the sunlight are

among the most important factors in building up the plant's food, this endeavor to get as much light as possible does not seem strange.

The ebony spleenwort does not seem to prefer rocks of any particular geological formation. It will grow on the face of a cliff, or in rocky woods, but seems to love the roadsides, where it can get more sunlight. It is at its best on some rocky bank where the soil is rich. It grows erect among the grass, and appears to be very stiff, but its fronds tremble in the slightest breath of air, as any one who has tried to photograph it can testify.

Asplenium eboneum Hortonæ. ×⅔.

The ebony spleenwort is found from Colorado and the Gulf States to Southern Canada. A form with very deeply cut pinnæ has been named *serratum*. A very beautiful form, found by Mrs. Horton in

Vermont, has been called *Hortonæ*. Its pinnæ are thinner and of a brighter green than the typical form, and they are incised or pinnatifid with wedge-shaped or serrate lobes. The stems are bright chestnut. The tall fronds are rarely fertile. It was afterwards reported from other states. The illustration is from a photograph of the Maryland plant.

An illustration showing the sori of the ebony spleenwort is given on page 47.

Bradley's Spleenwort. 16.

Asplenium Bradleyi.

Fronds oblong-lanceolate or linear-lanceolate, three to ten inches long, pinnate. Pinnæ oblong-ovate, obtuse, incised, or pinnatifid into oblong, toothed lobes.

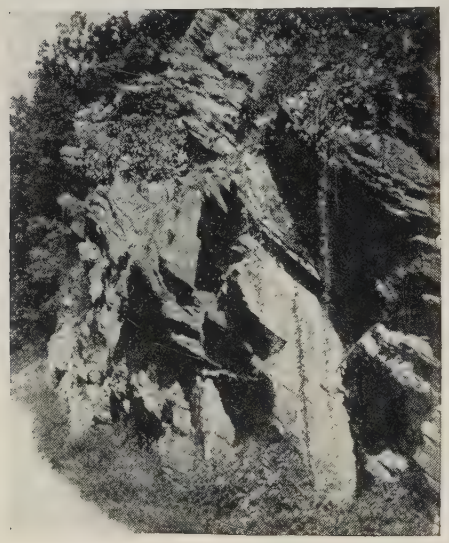
THE mysteries of the distribution of ferns will perhaps always remain unsolved. We do not know why it is that a fern should shun an apparently favorable situation for one in which it appears that nothing could live. Yet we are continually meeting with just such vagaries, as they seem to us. In 1893 a botanical friend brought in a specimen of Bradley's spleenwort, and was finally persuaded to tell the secret of its haunt. We were told to look for a certain rock about ten miles from the city. So two of us tramped to the place, and searched every likely rock by the road and up the hill in the woods, but saw nothing rarer than the obtuse Woodsia, which was abundant enough nearer home. A second

time, with more explicit directions, we took the walk, and found the fern so near the place we had first visited that

Bradley's Spleenwort. $\times\frac{3}{5}$. *a*, from Maryland; *b*, from Kentucky.

we felt rather provoked with it. How unpromising that high bare wall seemed as it rose sheer from the ground with not a tree between it and the afternoon sun! Yet

there we found the fern, perfectly fresh and evidently well established. Some of the plants were growing in the tiniest cracks where they had little room for their roots, but the majority of them sprang from the deeper crevices. A few of the finest plants were growing close to the ground in a sort of little cave formed by the overhanging base of the cliff. Here they were shaded by weeds in front of them.



The Haunt of Bradley's Spleenwort.

The hardiness of the fern is one of its most striking characteristics. On one occasion we visited the place in August, when there had been extremely dry weather for three or four weeks, and even the most exposed plants were fresh, and were only a little bronzed upon the surface. When a cross-section of a pinna is examined under the microscope we see that the cuticle, or layer composed of the outer cell-walls of the surface of the leaf, is very thick, and it must be very effective in preventing the escape of moisture from the plant.

The fronds are of a rather glossy dark-green color, and with their dark-brown, polished stipes are one of our most beautiful ferns, especially as seen growing. It does very well in an indoor fernery, although it changes its appearance

somewhat. The pinnæ are a little crinkled naturally, but become much more so in the house, and the whole plant reminds one of a very much "crisped" ebony spleenwort, and it acts towards the light in about the same way. The fronds springing from the side of the rootstock away from the window grow backward at such an angle that the brightest rays of light fall upon the upper surface at right angles. Those which are forced to grow towards the window usually have the upper third, or more, bent downward, and the pinnæ on the lower part are twisted so as to be about parallel to the tip. In other words, practically all the green surface of the plant is perpendicular to the brightest rays of light, and in this way receive the greatest possible amount of illumination. This behavior may explain why the fern presses so closely against the rocky wall on which it grows. Most of our rock-loving ferns are so firmly rooted that it is a matter of some difficulty to get a specimen with the rootstock, but in trying to collect simply the fronds of Bradley's spleenwort one has to be very careful not to pull up the entire plant.

Bradley's spleenwort was collected with a number of other ferns by the man whose name it bears, and was not noticed by him until it was put in press. It is one of our rarest ferns. It ranges from New York, where a single plant was seen, to Georgia, Arkansas, and Missouri.

The frontispiece shows the fern as it grows upon the rocks.

Mountain Spleenwort. 15.

Asplenium montanum.

Fronds two to eight inches long, ovate-lanceolate from a broad base, pinnate. Pinnæ ovate-oblong, the lowest pinnate or pinnatifid with oblong or ovate, toothed lobes, the upper ones becoming simpler.

MRS. PARSONS writes enthusiastically of finding the mountain spleenwort in Ulster County, New York; and well she may, for it is a rare fern, and is very scarce at its northern limits. It has been seen in one or two stations in Connecticut, in New York, and southward to Georgia, Alabama, and Arkansas, but there are many botanists who have never seen it except as herbarium specimens. Our own first specimens were growing in the shade near the base of a sandstone cliff in the Virginia mountains. In the damp air of the little gorge they throve wonderfully, one frond being seven inches long. A slightly smaller one from the same plant is shown at the left of the illustration on page 156. Some tiny, stunted plants clinging to a bare rock a mile away seemed almost like another species.

We at first thought the "find" was the rue spleenwort, but only a beginner should make such a mistake. The mountain spleenwort has a narrower frond in proportion to its length, and is rather less divided than the other species, which is inclined to be tripinnate below. The stipe of the rue spleenwort is brown only at the extreme base, and it is grooved deeply in front and slightly on the sides. The rachis and upper two-thirds of the stipe of the mountain spleenwort are flat, and with two parallel grooves in front.

The brown color extends perhaps a third of the way up the stipe.

Some years later we again found the mountain spleenwort, this time in company with Bradley's spleenwort.

Mountain Spleenwort.

Around at one end of the cliff and higher up the hill we saw it growing in small rosettes pressed closely to the rock. The larger fronds resemble somewhat the small ones of the rarer species, so that it was overlooked by the friend who

told us where to find Bradley's spleenwort, but we were renewing an old acquaintance and recognized it at once. Here again the stems will help us out when we are in doubt. In Bradley's spleenwort the stipe and the lower part of the rachis are brown, and the entire stem, except near the flattened base, is grooved in front, with a slight ridge down the middle of the groove. The mountain spleenwort is thicker in texture and is of a rather greenish-blue color.

The Mountain Spleenwort. $\times \frac{3}{5}$.

The fronds are evergreen and do not turn brown until early in their second summer. When young, the sori are so long and narrow that it is surprising to see how completely the under side of the pinna is covered by the mature spore-cases.

In the illustration the plant in the middle is from Maryland, the other two being from Virginia.

Rue Spleenwort; Wall-rue. 14.

Asplenium ruta-muraria.

Fronds one to seven inches long, deltoid-ovate, two- to three-pinnate at the base. Pinnæ pinnate, or bipinnate near the base of the frond, with narrowly wedge-shaped to roundish-obovate segments which are toothed or incised at the apex.

THE wall-rue or rue spleenwort is abundant in Europe, where it grows on rocks and old walls, but with us it is by no means common. It is, however, not as rare as the mountain spleenwort, and

Rue Spleenwort. ×¾.

should be looked for wherever there are outcroppings of limestone. It is a very hardy fern and can withstand great extremes of heat and cold. It is found as far north as Ontario, and south to Alabama. It grows on sunny, exposed cliffs, or boulders. The two fronds shown at the left of the illustration were obtained from crevices

between the stones of an old stone bridge on the "Valley pike" in Virginia.

It is one of our smallest ferns, and clings so closely to the rocks that it often takes a sharp eye to distinguish it from a bit of moss or similar vegetation. Fronds an inch in length may bear sporangia, but they are usually two or three times as large before reaching maturity. We have seen some very large specimens from Germany that are about seven inches long. The wall-rue is quite variable in the shape of the segments of the fronds, and some forms of it might be mistaken for the mountain spleenwort by the inexperienced student. We have already told how the two may be distinguished, on page 154.

Asplenium fontanum.
(Reduced.)

One other small species of spleenwort, *Asplenium fontanum*, has been reported from Pennsylvania and Ohio, but each time the specimens were apparently collected by accident, and were not recognized until it was too late to rediscover the locality. It is a small fern, four to nine inches tall, with pinnatifid or pinnate pinnæ; their segments dentate with spinulose teeth.

The illustration is from a photograph of European specimens.

Narrow-leaved Spleenwort. 35.

Asplenium angustifolium.

Fronds one to four feet tall, oblong-lanceolate, pinnate. Pinnæ thin, short-stalked, linear-lanceolate, acuminate, entire or finely crenate, those of the fertile frond narrower.

LTHOUGH it grows from southern Canada to Georgia and Missouri, the narrow-leaved spleenwort is one of the ferns that is found only on a red-letter day. Going along some tiny stream or skirting the edge of a swampy hollow in the woods, we see before us a clump of the silvery spleenworts that suddenly resolves itself into something else. There is no mistaking the nearly entire, linear-lanceolate pinnæ that seem too fragile for our northern climate, and we have added one more treasure to our list. It is true that these two ferns are unlike in texture and in the cutting of their foliage, but there is an indefinable something in the way they "hold themselves" that makes it hard to tell them apart when at a short distance from them. Perhaps for this reason it has been overlooked in many localities where it grows.

Miles away from a certain city, a river hurries down between steep hills at whose base is a flood-plain formed of silt deposited in times of overflow. In this rich soil, just at the base of the hill, a small colony of this spleenwort has found shelter beside a large rock where it is shaded by papaws and spice-bushes and the overhanging trees. Nettles, great ragweeds, and touch-me-nots crowd around with

Narrow-leaved Spleenwort. $\times \frac{2}{3}$.

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many silvery spleenworts, Christmas ferns, and other plants. Not many feet away is a small stream beside which we had often eaten lunch when on a tramp in search of Mertensia and walking-ferns, Dutchman's-breeches and showy orchis in the spring, yet the ferns had kept out of sight for six years or more until we finally walked "right on top of them" and could not help seeing them. Then began a search for others, but these seemed to be the only ones there.

Sori of Narrow-leaved Spleenwort. $\times 5\frac{1}{2}$.

It is an extremely "local" plant, as the botanists say, though it does not seem partial to any particular kind of soil. In another place are some fine plants at the edge of a wet spot in the woods where the soil is quite different from that in the place mentioned above. One of these plants was put in a low woodland where it thrives surrounded by swamp-cabbage, nettles, touch-me-nots, rich weed, and May-apples. Near Baltimore it is seldom fertile, and this may account for its rarity there and elsewhere. In 1902 the single plant last mentioned produced three fertile fronds, or as many as the two entire clumps. These fronds

Narrow-leaved Spleenwort.

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can be told at a glance by their much narrower pinnæ which are somewhat uneven on the upper side. The fertile fronds do not appear until August.

Silvery Spleenwort. 37.

Athyrium thelypteroides.

(G. *Asplenium thelypteroides;* B. *Aspl. acrostichoides.*)

Fronds two to five feet tall, pinnate, with numerous linear-lanceolate, pinnatifid, pubescent pinnæ. The lobes obtuse, minutely toothed, or even crenate.

ALONG the banks of streams that flow through rich woods we find the silvery spleenwort in its greatest perfection. There it forms small thickets, waist-high, with now and then a giant reaching to one's shoulder when held erect. It does not show its true size early in the summer when there are only the sterile fronds, but about the end of June the much taller fertile ones begin to come up, and add greatly to the stately appearance of the fern. Sometimes only the upper pinnæ bear fruit-dots, but large fronds may have every pinna fertile. W. N. Clute has pointed out that "although they do not grow in full sunlight from choice, they are most fruitful in such situations." The elongated sori, which form a double row on each lobe, are pale green at first. Later, as the sporangia turn dark brown or black, and push back the indusia, they have the silvery appearance to which the fern owes its name. Flowerhat, the frivolous maiden in Mrs. Wright's delightful book, says of them, "What an exquisite cool moonlight shade of green they spread under

Silvery Spleenwort. (Reduced.)

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the oaks; but why are they not called Feather-stitched Silver Ferns? Spleenwort is so suggestive of herb tea and a mussed-up liver!"

A casual observer would say that the sori are of the true *Asplenium* type; that is, long and narrow, and attached to the upper side of the veins, but frequently near the tip of the pinnæ some of the sori are curved so as to cross the veins. (See page 47.) When this is carried to the limit we have two sori placed back to back on opposite sides of the vein. For this reason our fern, which we must still call a spleenwort for want of a better common name, unless we adopt Flowerhat's, is put in a separate genus, *Athyrium*.

The pinnæ and stalks of the silvery spleenwort are covered with hairs that make it quite unlike any other fern that resembles it in general outline. Small fronds are quite like the New York shield-fern, but the latter is very slightly pubescent, and never has the coarse, almost shaggy appearance of the spleenwort when young. Close to the rootstock the stalks have a few slight, tooth-like projections that distinguish it at once from the New York fern. The lobes are generally quite close together, and the pinnæ distant, but when the first fronds are mowed down in early summer the second growth often looks like a different species, for the pinnæ are then close together and the lobes distant. Such fronds are apt to have the lobes crenate, a peculiarity we often meet with in very large fronds.

The silvery spleenwort is found from Nova Scotia to Minnesota and south to Georgia and Alabama.

Silvery Spleenwort.

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Lady-fern. 36.

Athyrium filix-fœmina.

(G. and B. *Asplenium filix-fœmina.*)

Fronds one to four feet tall, ovate-oblong or broadly lanceolate, bipinnate. Pinnæ lanceolate. Pinnules oblong or oblong-lanceolate, acute, serrate, incised, or pinnatifid, distinct or confluent on the secondary rachis by a narrow margin.

HEN a fern exhibits as many variations as the lady-fern, it is excusable if the beginner mistakes it for some other fern now and then. We once received in exchange a package of four or five different varieties with about as many different generic names attached. Perhaps it is taken for the spinulose shield-fern as often as any other, and the hay-scented fern bears some resemblance to it. From the former it is distinguished by having only two (instead of three to seven) fibrovascular bundles in the stipe. The hay-scented fern has but a single curved bundle, and the stalks and fronds are quite hairy, while the lady-fern is smooth except for a few deciduous scales on the stipe.

The lady-fern is a cosmopolitan species, being found throughout most of North America and Europe. It occurs in the greatest variety of situations, but is found in its most beautiful form in low, moist woodlands. In such situations, in spite of the competition with many other sturdy plants, it manages to hold its own and form dense clumps to the exclusion of nearly all other plants. They grow so closely that the stipes are long in proportion to the

Lady-fern. (Reduced.)

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frond, and it is not hard to find specimens three feet or more in height. In dry woods and in sunny places we find quite different varieties, and it is interesting to collect all the different forms of a given region. We must confess that the fern never seemed attractive until it was studied in this way. As three hundred or more forms have been described, it is evidently no easy task to correctly name every variety we come across, for the differences are so slight and the distinctions so subtle in most cases. In the illustration on the opposite page are shown pinnæ of five varieties or forms. Of these, *laxum* and *incisum* are least common; *ovatum* and *distans* are from the moister thickets, and *angustum* grows where it is drier.

In view of its great variability we ought to have some sure means of identifying the lady-fern whenever it is met with. Long practice makes one familiar with it, but for the beginner we would recommend an examination of the stems of all suspicious ferns. The stipe is ridged on the sides at the extreme base, and along these ridges, close to the underground rootstock, are a few tooth-like projections that are readily detected by running the stipe between the thumb and finger. But two other species have this peculiarity, the silvery spleenwort and at times the ostrich-fern. But the silvery spleenwort is always hairy, and the stem of the ostrich-fern is much more deeply grooved in front and flattened on the sides, and the rachis is narrowly winged on each side, its pinnæ are merely pinnatifid with entire lobes, and the lower pinnæ are much reduced. Fronds of the lady-fern from three and five-eighths up to forty-nine inches tall

were examined, and the teeth were found in every instance.

The lady-fern is put in the genus *Athyrium* on account of the curved sori that cross the veins, as shown in the accompanying illustration. Comparing it with the picture on page 47 we see that the folding is not carried to the same extent as in the silvery spleenwort, and the sori seem never to be double as in that species. The fertile fronds,

Sori of Lady-fern. ×5½.

which are taller and with more distant pinnæ than the sterile ones, come up in June, and the spores begin to ripen in July. They germinate very readily, and are, perhaps, the best for experiments at home. To obtain them we need only pick heavily-fruited pinnæ and let them dry out in a paper box or bag for a day or two until the spores are

Pinnæ of *Athyrium filix-fœmina*. × ¾.
a, var. *ovatum*; *b*, var. *laxum*; *c*, var. *distans*; *d*, var. *incisum*; *e*, var. *angustum*.

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discharged. The prothalli and young plants in all stages are readily found on moist earth wherever the lady-fern is at all abundant.

In spite of its being a favorite of the poets, it must be confessed that the lady-fern is not nearly as attractive as many of our other ferns. There is a certain coarseness about it that detracts from its appearance, and makes it inferior to the spinulose wood-fern, with which beginners are apt to confound it. Is it the finishing touch of the bristly tips to the lobes that makes the latter so much more attractive, or does the eye take in almost unconsciously the greater coarseness of the lady-fern and disapprove of it? Yet it has been called the "queen of ferns," and many poets have sung its virtues. Campbell says:

"If you would see the lady-fern
In all her graceful power,
Go look for her where woodlarks learn
Love-songs in a summer bower."

The lines of Scott are also familiar:

"Where the copse wood is the greenest,
Where the fountain glistens sheenest,
Where the mountain dew lies longest,
There the lady-fern is strongest."

The way the fern has of growing in moist, shady woods and beside streams, of themselves attractive spots, has made an impression on the poets, for this is nearly always mentioned. Miss Pratt says:

"Seek her not in early May,
For a Sibyl then she looks,
With her wrinkled fronds that seem to say,
'Shut up are my wizard books.'

Lady-fern and Sensitive Fern.

Page 173.

Then search for her in the summer woods,
Where rills keep moist the ground,
Where foxgloves from their spotted hoods
Shake pilfering insects round."

Who has not seen just such a place at the base of some steep hill, where the soil is black from the washings of the slopes above? It is the spirit of the place and not the fern that has inspired the poets. Where else can we find freshness and beauty in midsummer, when

"Noon burns up the mountain; but here by the fall
The lady-fern flourishes graceful and tall.
Hours speed as thoughts rise, without any concern,
And float like the spray gliding past the green fern"?

EDWIN LEES.

Hart's-tongue. 40.

Scolopendrium vulgare.

(B. *Phyllitis Scolopendrium.*)

Fronds simple, or variously forked at the tip, entire or wavy-margined, oblong-lanceolate from an auricled, heart-shaped base.

AMERICAN students who use some of the German or French botanical text-books may be inclined to wonder why the hart's-tongue is taken as the typical fern for study, because it is anything but "*vulgare*" on this side of the ocean. We were told by a European botanist that it is common only in certain localities, and that it happened to have been fully studied and described by an author living where it was abundant. Be that as it may, the later books seem to be taking the male fern as the type, for it is abundant in Europe. It is a pity that

Hart's-tongue. × $\frac{1}{5}$.

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a recent American text-book, filled with fine photographs and many original drawings, should have chosen the same species, so rare with us, and copied the illustrations of the German author Wossidlo instead of using some familiar American fern.

Hart's-tongue. ×½.

In America the hart's-tongue is one of the most local ferns, being restricted to certain limestone formations. It has been found in a few spots in central New York, Tennessee, New Brunswick, and Ontario. It prefers shaded ravines where the air is charged with moisture and the soil is composed of humus from decaying vegetation. The fronds are usually simple, but may be variously forked or crested at the tip, especially when the plant is cultivated. A number of varieties of this sort have been named.

The name *Scolopendrium* comes from a Greek word meaning "centipede," in allusion to the rows of elongated sori, along each side of the midrib, which are supposed to resemble the legs of that creature. The genus is regarded as distinct from *Asplenium* because the sori face one another in pairs from two adjacent veins. The illustration on page 48 shows how the indusia are folded over toward one another. They are pushed back and finally hidden by

the maturing spore-cases so that the sori finally come to be oblong patches of sporangia as shown in the accompanying illustration. On some fronds from Europe many of the

Old Sori of Hart's-tongue. ×5.

sori are a trifle over three-fourths of an inch in length and about three thirty-seconds of an inch broad. Lindley calculated that a single frond of this fern produced eighteen million spores.

Walking-fern.

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Walking-fern. 20.

Camptosorus rhizophyllus.

Fronds three to twelve inches long, simple, narrowing from a broad heart-shaped or auriculate base to a long slender prolongation, or abruptly rounded. Veins reticulate.

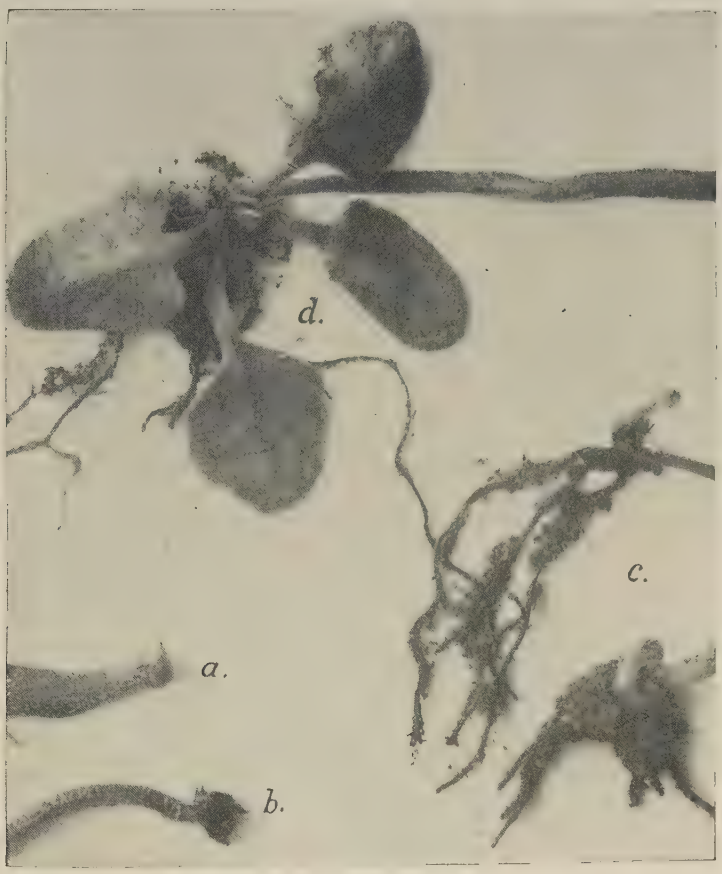
NEAR the base of some cliff, or on moss-covered boulders, we may now and then come across the curious interlacing fronds of this wide-spread but not abundant fern. To the uninitiated it looks like almost anything else than a fern, but if we turn the fronds over, there are the tell-tale sori that proclaim it a near relative of the spleenworts. Early in the summer we see the new fronds uncoiling, their slender tips being so long that they do not stretch to their full size until many of the sori are nearly mature. These first appear as whitish lines scattered over the under surface and even far along the slender tip, but the indusia are soon pushed back, leaving only the brown spore-cases visible. As the veins form an irregular network, the sori, which are always borne on them, are not arranged with the neatness and precision seen in most ferns. They face in all directions, and are straight, or curved, or bent sharply, or even forked, as we can see from the illustration on page 49. The only apparent regularity is that they tend to face one another in pairs near the margin of the frond. Never was scientific name more appropriate, for *Camptosorus,* is derived from Greek words meaning "bent fruit-dot." The specific name, *rhizophyllus,* refers to the "rooting leaf."

This peculiarity of the leaves is not apparent in early summer, but in August, when the fronds are fully developed, we will notice that the tips of the longer ones are nearly all against the rock, or pushed down into the moss

Walking-fern. (Natural size.)

upon it. A little later most of them have young plants with two or three tiny fronds growing upon the tip. By examining a number of the plants we will learn how these young ones are developed, and shall see the reason why the tips of the fronds are thrust into the moss. At first there is a slight thickening, as shown at *a*, which is enlarged

five and one-half times. Soon a mass of fine rootlets (*b*) is formed, and then a tiny frond begins to uncoil (*c*). Others



Development of the Walking-fern. ×5½.

follow in rapid succession until by winter there is a little rosette of three to six leaves pressed close against the moss (*d*). The walking-fern is evergreen, so that the young plant retains its connection with the parent until the fol-

lowing summer, when the large frond withers away and the young plant must lead an independent existence. Occasionally one finds a specimen with three, or even four, plants in a row. This occurs only when the summer's growth is very luxuriant, for the connecting fronds do not last longer than a year. Some time ago we started an experiment to determine at what stage the young plant could be cut off from the parent and survive. The tips of several fronds, at the stages *a*, *b*, and *c*, were cut off with an inch or less of the prolongation and planted in a pan of moist earth. In two or three weeks several of them sent up small fronds, even though they were barely as far advanced as stage *b* when planted. They did not seem very vigorous and were evidently greatly handicapped by the rough treatment, and lack of aid from the parent plant. At the time of writing, six months later, the young plants were in just the same condition, each with a single frond. It may be that they will begin to grow again in the spring. It rarely happens that our ferns continue to grow during the winter when planted indoors, and for them the coming of spring does not precede by any great length of time the new birth of their outdoor relatives.

The fronds are not infrequently forked at the tip. At times the auricles at the base of the frond have slender prolongations which may take root.

The picture on page 178 shows how the fronds grow close to the surface of the rock, and not arching over like the frond on page 180, which was bent in order to get it on the page. We have seen that Bradley's spleenwort and

other ferns grow close to the rocks on account of the action of light on them. In the case of the walking-fern it would

Some Fronds of the Walking-fern. $\times \frac{1}{2}$.

seem as if gravitation played some part, at least. In the illustration most of the fronds are bent downwards, and those which grow upwards have their tips curved over to the rock, which slopes at an angle of about forty-five degrees.

If the picture be held upside down or sideways, the plants look unnatural. Two fronds from a plant at the edge of a receding rock were unusually long and the tips were dropped vertically downwards as if trying to reach the ground. The fronds of plants grown indoors are nearly all short and abruptly rounded, like a number of those in the illustration, but the few prolonged ones grow either away from or towards the window as if the light had no influence upon them, and send down their tips in the usual manner.

The walking-fern is found from Southern Quebec to Minnesota and south to Kansas, Georgia, and Alabama. It prefers limestone, though fine plants are often seen on granite and gneiss and other rocks.

Long Beech-fern. 34.

Phegopteris polypodioides.

(B. *P. Phegopteris.*)

Fronds triangular, longer than broad (four to nine inches long exclusive of the stipe), hairy on the veins, pinnate with a winged rachis. Pinnæ linear-lanceolate, the lowest pair deflexed and standing forward; the divisions obtuse, oblong, entire. Sori near the margin.

HE long beech-fern is found in damp, rich woods, where its earches out some little hollow that it may fill with its rather odd fronds that grow horizontally at the summit of the erect stipe. It appears to be equally at home on some decaying log, now so soft that its rootstock can penetrate it easily. According to Clute it "is seldom found except in the vicinity of rocks." Our own experience with it is too limited to be of

much value. The species is said to be common in the North, yet we have found less than twenty plants, all told, in Maine, New Hampshire, Connecticut, and New York. It must have "just happened so," for no one regards it as a rare fern. It is thicker in texture than the other two species, but seems to be no hardier, for all three die early in the fall.

The fruit-dots of the species of *Phegopteris* are similar to those of *Polypodium*, but in other respects the ferns are closely related to the shield-ferns, so that some botanists are even inclined to put the two into one genus. For one thing, the stipes of all Polypodiums are articulated or jointed to the rootstock, so that when broken away a distinct scar is left. But the stipes of the beech- and shield-ferns are continuous with the rootstock, and do not break away at a definite point any more than a branch of an apple-tree will when torn off forcibly. It is an important difference, in some way connected with the remote ancestry of the ferns, and is deemed of more importance than the perhaps accidental absence of indusia from the fruit-dots.

In the South the long beech-fern gives way to the broader species which is so closely related that it is not always easy to tell them apart. Typical fronds are quite unlike, but they grade into one another imperceptibly, and in a large collection there will usually be forms that are hard to name with certainty. Even after an examination of about one hundred sheets of specimens in the National Herbarium and in our own collection, we are still uncertain just where to draw the dividing line.

Long Beech-fern. × ¾.

Page 186.

Usually the frond of the long beech-fern is about like the one in the illustration in general outline. The stipe and under side of the midrib are somewhat scaly, and the frond is pubescent, especially on the veins underneath. But the broad beech-fern is also scaly and pubescent, though rather less so. Much importance is attached to the position of the lowest pair of pinnæ, but here again the signs fail. As a rule the lowest pinnæ of the longer species are deflexed and stand forward, but this same peculiarity is often seen in the case of the broad beech-fern. In "Ferns of North America" Professor Eaton sums it up by saying that in general *P. polypodioides* is not so large and is less broadly triangular than *P. hexagonoptera*. The lowest pinnæ of the latter are decidedly longer and broader than the next pair, while in the former species the difference is very little, and they may even be somewhat shorter.

The stipe of the long beech-fern is nearly always pubescent, and is flattened and usually somewhat grooved in front. The broad beech-fern has a smooth stipe that is flattened in front, often with traces of grooves on the sides and in front, and except in forms approaching the long beech-fern there is a green line along each side of the stipe.

One little point which seems to be generally overlooked is that the lowest pair of pinnæ of the long beech-fern is separated from those next above by a noticeably wider space than is the case farther up, and the rachis is not winged at this place. The basal lobes of the pinnæ are joined to the rachis, but are cut off abruptly instead of running into wings as in the broad beech-fern. So that instead of the

Broad Beech-fern.

Page 188.

typical hexagons along the rachis of the broad species there are irregular squares. Every specimen in the National Herbarium showed this peculiarity, which was not possessed by a single specimen of the broad species. But certain doubtful forms from Maryland have this space, yet there are hexagons seen farther up the rachis. This is shown in the frond at the right in the illustration on the opposite page.

The long beech-fern is found from Newfoundland to Alaska, and south to Virginia, Michigan, Iowa, and Washington. It also occurs in Greenland and in Europe.

Broad Beech-fern. 33.

Phegopteris hexagonoptera.

Fronds as broad as or broader than long, spreading more or less horizontally at the summit of the stipe, which is six to eighteen inches in length; broadly triangular, slightly pubescent, or even glandular, and often with a few pale scales along the midribs underneath. Lowest pair of pinnæ usually much larger than those above. Pinnæ decurrent on the winged rachis.

The broad beech-fern is to be looked for in nearly all rich woods, although it has its favorite haunts in which it grows to perfection, while it is not found in other places where the conditions are apparently identical. Such anomalies in the distribution of ferns and other plants add to the interest of botanical excursions. The first trip in a new region is true pioneering, and brings its surprises and disappointments.

"Among the woods,
And o'er the pathless rocks I forced my way
Until, at length, I came to one dear nook
Unvisited, where not a broken bough

Broad Beech-fern. $\times \frac{1}{2}$.

Page 109.

Drooped its withered leaves, ungracious sign
Of devastation, but the hazels rose
Tall and erect, with milk-white clusters hung,
A virgin scene!—A little while I stood,
Breathing with such suppression of the heart
As joy delights in."

WORDSWORTH.

The moister spots in the woods are usually occupied by the lady-fern and the cinnamon-fern among others. Where it is somewhat drier, but still well down in the hollow where the soil washed from the surrounding slopes accumulates, the beech-fern luxuriates. It is very apt to grow in large clumps through which we may walk knee-deep in the fragrant fronds. Scattered all through the drier parts of the woods smaller plants are found, most of them being sterile, or fruiting very sparingly. In sunny places along the road the fronds are so contracted and folded together as to look like another species to the beginner. It is one of our most variable ferns, the fronds differing greatly in outline and in the cutting of the pinnæ. This is true to a certain extent of fronds on the same plant, especially as the pinnæ of the fertile fronds are apt to be somewhat contracted. But all the forms show a series of irregular hexagons along the winged rachis, except some that approach the long beech-fern in appearance. The characteristics of the two species were discussed when that fern was taken up. Two extreme forms of the broad beech-fern are shown on the opposite page, and others on page 192.

Early in the summer the first fronds have fully developed, but they are sterile. Other taller ones bearing the spores appear in succession later, so that a single plant will

produce six or eight fronds, each a little taller than the one preceding. The illustration on page 36 shows how the

Broad Beech-fern

stipes are scattered along the slender, creeping rootstock. The sori are not large (see page 50), and they have no indusium.

Broad Beech-fern.

Page 193.

The fronds have a pleasant "ferny" odor that is more perceptible when they are bruised. Late in the summer they are often found bleached nearly white, either completely or only the pinnæ on one side of the midrib or at the tip of the frond. They are killed by the first heavy frost, but those which survive light frosts turn to a beautiful shade of yellowish green.

The broad beech-fern occurs sparingly in the north, though it is found from Quebec and New England to Minnesota, and south to Kansas, Louisiana, and Florida.

A curious form with crested pinnæ has already been mentioned on page 16.

Oak-fern. 26.

Phegopteris Dryopteris.

Fronds broadly triangular, three to eight inches wide, smooth; ternate with once or twice pinnate stalked divisions. Segments oblong, obtuse, entire, or toothed.

AINTY" expresses the appearance of the oak-fern as well as any other adjective. To see it at its best we must go to the rocky woods where the soil is rich and moist, and there in the deepest shade we may be fortunate enough to find it. Not that it is a rare fern, but it loves to hide in sequestered spots to be sought out by the enthusiast. There is no mistaking its bright green fronds, that cannot fail to impress one by their resemblance to a bracken in miniature, and the small, round sori placed rather near the margin. The

stalks are very slender and so translucent that the course of the fibrovascular bundles with their sheath of black tissue can be followed far up towards the tip of the frond.

The Oak-fern. (Reduced.)

Its great regularity of growth is one of the features of this fern, each pinna and pinnule and lobe having one just opposite to it, as a rule. It so happens that each of the two fronds in the illustration shows a slight irregularity. The

rootstock is quite long and slender, and it branches here and there so that the fronds of a single plant can cover quite a space. The sori are very small and placed rather near the margins of the divisions. There is no indusium; but the reasons for placing the beech-ferns in a separate genus from the polypody, which is also destitute of indusia, apply with equal force to the oak-fern.

This fern is found from Newfoundland to Virginia. It also occurs in Greenland and Europe

Limestone Polypody.

Phegopteris Robertiana.

(G. *P. calcarea.*)

Fronds eight to eighteen inches long, ternate, deltoid-ovate, bipinnate, the lowest pinnæ much the largest, pinnatifid or again pinnate, upper pinnæ smaller, pinnatifid, lobed or entire. The stalks pale, glandular.

HIS fern would be taken, at first sight, for a large form of the oak-fern, and many botanists still regard it as such. The limestone polypody may be told from the other species most readily by its glandular stalks. When seen under a lens they appear to be covered with short hairs having knobs at their ends. The stalks of the oak-fern are smooth. The three divisions of the frond of the latter fern are nearly equal, while in the limestone polypody the terminal one is much larger than the other two. It is also a much coarser-looking plant than the oak-fern. Its fronds grow more erect than those of the oak-fern, which are generally nearly horizontal.

The limestone polypody is found from Labrador to

Limestone Polypody. $\times\frac{3}{5}$.

Quebec and Iowa, Minnesota, and Manitoba. It has also been reported from Idaho.

Marsh Shield-fern.

Page 198.

This fern has been given a variety of names by different botanists. Besides the two used above, it is also known as *Phegopteris Dryopteris Robertiana.* The earliest name applied to it was *Polypodium Robertianum.* This was more than a century ago, when the polypodies and beech-ferns were all put in the same genus, and the name limestone polypody, as well as the specific name, *calcarea,* was given because it loves that particular kind of rock, or is supposed to do so.

Marsh Shield-fern. 31.

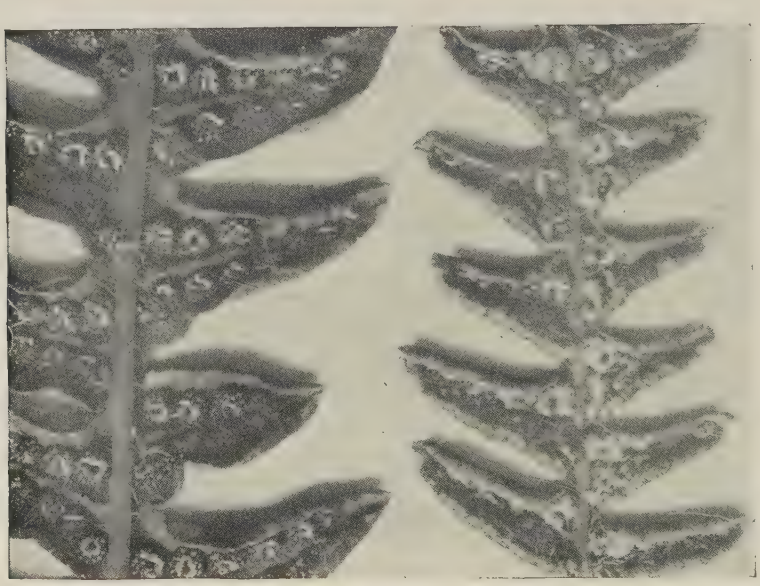
Nephrodium Thelypteris.

(G. *Aspidium Thelypteris;* B. *Dryopteris Thelypteris.*)

Fronds pinnate, lanceolate or oblong-lanceolate, very slightly or not at all narrowed at the base, nearly smooth. Pinnæ linear-lanceolate, deeply pinnatifid, with oblong, entire, obtuse lobes that appear acute by the infolding of the edges when in fruit. Veins once or twice forked.

IN wet meadows or fringing some little pond, or by the roadside ditches, we often see the marsh shield-fern with its primly erect, stiff-looking fronds of a rather dull, pale-green color. Because they usually grow among grasses and other dense vegetation the stipes are very long in proportion to the size of the frond. When growing in full sunlight they may not be more than twelve or fifteen inches in length; when partly shaded, as when they grow beside bushes, the fronds are two feet or more long. Some plants found growing under

dense bushes shaded by forest-trees stretched up toward the light until their tips were over four feet above the ground. They plainly showed the effects of the unaccustomed darkness, for the stalks were weak and slender, and the pinnæ were far apart and very thin. It goes almost without saying that these plants were sterile, for the marsh shield-fern fruits well only when it receives abundant sunlight.



Sori of the Marsh Shield-fern. ×5½.

It is a true *Nephrodium* — that is, the sori are covered by kidney-shaped indusia — but the margins of the lobes are often so much recurved as to appear like the indusia of a brake, as shown in the illustration on this page. The larger of the two pinnæ has the margins less folded, probably because the frond was more shaded.

Massachusetts Fern.

Page 201.

The illustration on this page shows part of a pinna from a frond growing up in a bush by the roadside. The margins are not at all recurved. As the spore-cases of the more heavily fruited fronds develop and enlarge, the edges of the lobes are partly pushed back, and the space between them is filled with a mass of closely-packed sporangia. Such a frond is noticeably heavier than the sterile ones, and

Sori of the Marsh Shield-fern. $\times 5\frac{1}{2}$.

its appearance as the powdery spores are scattering has given it the name "snuff-box fern." The name *Nephrodium* comes from the Greek, and refers to the shape of the indusia. Some years ago American botanists called this

genus *Aspidium*, a name which is also derived from the Greek, and means "a small shield," the indusium being of that shape, especially in that section which is now usually called *Polystichum*. Many of those who do not now use *Aspidium* are inclined to call the genus *Dryopteris*, a word meaning "oak-fern." The true oak-fern, however, is a species of *Phegopteris*. In Europe the genus is also called *Lastrea*, in honor of De Lastre, a French botanist.

The fertile fronds come up late in July, and the spores ripen in September.

One often notices that the upper part of the frond is twisted, sometimes even half-way round. The illustration, which is from a photograph of fresh specimens, shows two fronds that are twisted at the tip. It will also be noticed that the tips of the pinnæ on opposite sides of the frond are somewhat inclined to curve around toward one another. This and the twisting of the tip are most pronounced in the case of the two fertile fronds, the one at the center and the frond to the left of it.

The marsh shield-fern has been found from New Brunswick to Manitoba, and south to Kansas, Texas, and Florida. It occurs also in Europe and in Asia. It shows perhaps less tendency to grow irregularly or with forking fronds than any of our other ferns. Quite recently, however, a very remarkable form of it was discovered by Mrs. Puffer at Sudbury, Mass. *Nephrodium Thelypteris* f. *Pufferæ* has not only the tip of the frond forked, but the pinnæ are crested (repeatedly forked), the lobes of the crowded, overlapping divisions being more or less irregular.

Nephrodium Thelypteris f. Pufferæ. (Reduced.)

Page 204.

Massachusetts Fern. 30.

Nephrodium simulatum.

(B. *Dryopteris simulata.*)

Fronds eight to twenty-four inches long, oblong-lanceolate, pinnate. Pinnæ lanceolate, pinnatifid, the segments obtuse, entire, finely pubescent.

HERE was some excuse, perhaps, for the older botanists with their very imperfect knowledge of the New World, when they called every plant *Canadensis* this or *Virginicum* that. It seems a pity, in this day and generation when we are supposed to know a little about geography, to name a fern after a state, as if the limits of one outlined the range of the other. Unfortunately there seems to be no good name to give this particular plant, so we are forced to call it the Massachusetts fern because it was discovered in that state. Since then it has been found in different localities from Maine to Maryland, and has been reported to occur in Missouri and Indian Territory. It is intermediate between two common ferns, the marsh shield-fern and the New York fern. The specific name was given, however, because it "simulates a peculiar woodland form of *Asplenium filix-fœmina*" (the lady-fern), and not from its resemblance to the other two species.

In 1894, while on a botanical trip on the Coastal Plain near tide-water, we came across large patches of the Massachusetts fern in a low woodland where the two chain-ferns and the cinnamon-fern are abundant. We could not name it offhand, for it was evidently neither of the two

related species, though closely resembling them. Fortunately a couple of fronds were preserved, for two months later Mr. George E. Davenport described the fern as a new species from New England, and stated that he had had it under observation for some time.

Its resemblance to the lady-fern is not so great as to cause much trouble. The latter species is never hairy and the pinnæ are pinnate with more or less incised pinnules. The pinnæ of the Massachusetts fern are deeply pinnatifid with entire lobes, and they, as well as the stalk, are hairy. The stipe lacks the characteristic teeth found on the lady-fern stipes.

The marsh-fern is smoother than the other two, it is thicker in texture, and its pinnæ are usually broadest at the base, and the lowest pairs are scarcely shorter than those above. The veins are nearly all forked, in the sterile fronds, and often simple in the fertile ones, and the margins of the fertile lobes are much recurved.

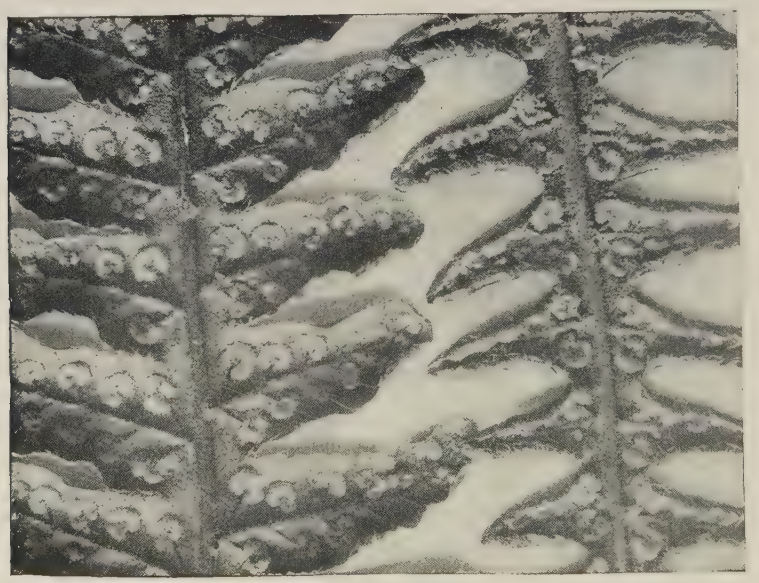
The New York fern has simple (not forked) veins, and the pinnæ are broadest at the middle, except the lower ones, which are very much smaller than those above. The pinnæ and stalk are hairy. The indusia are very small, and the edges of the lobes are not at all recurved.

The Massachusetts fern, as pointed out by Mr. Davenport, "holds itself" quite differently from the other two, though not in a way to be described. Its veins are simple, and the pinnæ are broadest at the middle, the lower pairs being nearly as long as the middle ones. The pinnæ and stalk are hairy. It is darker in color than the other two

Massachusetts Fern.

Page 207.

ferns, and the sori are quite large. When forced to grow in full sunlight the edges of the fertile lobes are quite as much recurved as in the marsh-fern, and even in the densest shade they are somewhat folded over, as shown in the illustration. The differences in the stalks are pointed out in the key.



Sori of the Massachusetts Fern. ×5½.

This fern loves low woods and thickets where sphagnum is abundant. In such places the New York fern is rarely found and the marsh-fern is nearly always sterile. Early in the summer the first fronds appear, either scattered along the creeping rootstocks or clustered at their ends. These fronds are usually sterile, though the larger ones may bear a few scattered sori. Some of them are nearly twice as broad, in proportion to their length, as those shown in

the illustration on page 207. Late in July the much taller and more erect fertile fronds come up, and in a few weeks the sterile ones are nearly hidden beneath this new mass of foliage. The spores have barely time to ripen before the frosts cut down the tender fronds. It is not an easy fern for the collector to deal with, for the stalks are quite brittle and the pinnæ are easily broken. It is also subject to the attacks of insect larvæ that disfigure it.

New York Fern. 29.

Nephrodium Noveboracense.

(G. *Aspidium Noveboracense;* B. *Dryopteris Noveboracensis.*)

Fronds one to two and a half feet long, pinnate, tapering both ways from the middle. Pinnæ thin, lanceolate, finely pubescent beneath, pinnatifid with oblong, blunt lobes which are usually entire. Veins not forked.

N any moist woodland we may look for just such a clump of the New York fern as is shown in the illustration on page 6. It is not a true marsh species, but it loves to gather around the edges of wet places in the woods, where it gets the benefit of the abundant moisture, and of the rich soil washed down by the rains. Its slender, creeping rhizome enables it to spread rapidly and to completely cover the ground, and at times we may find patches of it that are a rod or more across. When it strays up the hill from the more congenial spots it becomes smaller, and is not apt to bear many fruit-dots. At the same time its color becomes lighter, and the fronds are stiffer and evidently better fitted to get along with a small water-supply than its more favored relatives.

The sori are quite small, and do not become very noticeable until rather late in the summer. The edges of the

The New York Fern. (Reduced.)

indusia are glandular, that is, covered with hairs that are tipped with a sticky secretion. This peculiarity is shared by the two preceding species, though the indusia of the

marsh-fern are less glandular than the others. Even when the spores are nearly mature the fruit-dots are not much larger than before, and they rarely cover the surface of the lobes as those of the Massachusetts fern are apt to do.

Sori of the New York Fern. $\times 5\frac{1}{2}$.

Few of our ferns are as delicate in texture or as graceful as the New York fern, and its abundance does not make it lose its charm. It is one of the most readily recognized ferns we have. Only two other species taper towards the base as it does. The lower pinnæ of the silvery spleenwort are occasionally much contracted, but the small fronds that show this peculiarity are much coarser and more pubescent than those of the New York fern. The latter also lacks the characteristic teeth at the base of the stipe. The stipes are also less fleshy and nearly smooth. The lower pinnæ of the ostrich-fern are also reduced, but it is quite different from this species. Its stipe is very much flattened at the base, while higher up it is deeply grooved. It is not at all hairy.

Fragrant Shield-fern.

Page 212.

We have already shown how to tell the New York fern from the marsh-fern and the Massachusetts fern.

Sometimes the lobes of the pinnæ are somewhat crenate, though they are generally entire. The tips of the fronds and pinnæ are not infrequently forked, but on the whole the fern shows little tendency to vary. A form with more rigid fronds that are quite glandular on the under side has been named variety *suaveolens*. It is sweet-scented when dried.

Fragrant Fern. 43.

Nephrodium fragrans.

(G. *Aspidium;* B. *Dryopteris.*)

Fronds four to twelve inches high, lanceolate, with linear-oblong, pinnate pinnæ, glandular and aromatic. The crowded divisions of the pinnæ oblong, obtuse, toothed, or nearly entire.

HE fragrant fern is not found south of New Hampshire, Vermont, and northern New York, though it occurs in higher latitudes, and grows in Greenland, Europe, and Asia. In spite of its wide distribution it is little known, and is one of the chief treasures of the collector. Unfortunately for the fern it is attractive to the layman as well, on account of the delicate fragrance of its fronds. The odor has been likened to that of raspberries, or primroses, or new-mown hay containing sweet-brier rose-leaves. To us it seems most like the fragrance of the ground-nut or wild bean (*Apios*). It is said that the Yakoots use the plant in place of tea, and Eaton, who tried the experiment, says that the infusion had a "not unpleasant and very fragrant astringency."

The plant in the illustration was found on a cliff by the shore of Lake Sunapee, N. H., where we sought shelter from a passing shower. Although it prefers shaded cliffs, it can adapt itself to sunny situations without suffering much harm. The dead fronds of the preceding year bend downward, and are curled in a characteristic way. They are not fragrant, although the pressed fronds may retain their odor for many years, according to Eaton. It will be noticed that one of the dead fronds in the illustration is forked.

The sori are quite large and nearly cover the divisions of the frond.

Spinulose Wood-fern. 53.

Nephrodium spinulosum.

(G. *Aspidium;* B. *Dryopteris.*)

Fronds one to three feet high, ovate-lanceolate, twice pinnate. Pinnæ oblique to the rachis, elongated-triangular, the lower pairs broadly triangular. Pinnules set obliquely on the midribs, connected by a narrow wing, oblong, incised or pinnatifid with spinulose lobes. Scales of the stipe pale brown.

LL the members of the genus *Nephrodium* may be called "shield ferns" from the roundish indusia that cover the sori. Our species may be roughly divided into two groups. The marsh-fern and the two related species are quite unlike the members of the other group, which are often called "wood-ferns." The fragrant fern stands somewhat apart, but beginning with the spinulose shield-fern we have a series of six or seven ferns that are clearly related to one another, although the two end members are quite unlike. To the beginner

Nephrodium spinulosum. × ½.

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they are apt to prove troublesome, especially when he finds the spinulose wood-fern or one of its varieties.

The typical form of the species is not abundant in America. Botanists living in the North have a better chance of finding it, though it has been seen as far south as Virginia and Kentucky. We shall never forget the first walk along a certain road, and the two fine plants growing just in sight on the bank of a little stream which we crossed. It was a "find" indeed, and the frond we then collected, from which the illustration was made, has always had a peculiar attractiveness, for it recalls vividly the thrill of pleasure on first seeing it, and the trouble we had later in weighing the evidence in our first real problem in fern-study. We could at that time rattle off all about the color of the scales, and the glands of the indusia, far more glibly than at present. Those scales! Were they "brown" or "pale brown," and was the center "dark" or "darker"? The indusia had long since withered, but the next year we saw that they were smooth and without glands on the margin, just as they should be in the typical form.

The spinulose shield-fern is to be looked for in rich woods, especially near streams. It does not grow in the wetter places as the common variety *intermedium* does. We have seen the latter on little mounds of earth barely reaching above the water in some woodland swamp. It may wander up the hillside, but is always found where the soil is rich and moist. In variety *intermedium* the fronds are oblong-ovate with oblong-lanceolate, spreading pinnæ, the lowest being unequally triangular-ovate. The crowded

pinnules are pinnately divided. The margin of the indusium is finely toothed and beset with minute stalked glands. The scales on the stipe have dark centers.

Sori of the Spinulose Wood-fern. ×5½.

This variety of the spinulose shield-fern occurs from North Carolina and Tennessee to Labrador and Alaska.

This and the Christmas fern are used more than any others by florists, who find that the fronds are a very satisfactory kind of "green" in making up designs. A writer in the "Fern Bulletin" was told by a New Orleans florist that they are sent south by millions and kept in cold storage until wanted. This is not a difficult matter, for the fronds are evergreen, though they turn brown early in the spring. All the evergreen wood-ferns behave alike at the approach of winter. The tissues near the base of the stipe turn

Nephrodium spinulosum intermedium. $\times\frac{1}{2}$.

Page 218.

brown and soften so that the frond falls over to the ground and is covered by dead leaves from the trees above. The fibrovascular bundles remain intact, and for that reason it has been suggested that the fronds are of some use to the plant in the spring. This seems hardly probable, for the downward circulation of sap in the stipes must be seriously interfered with, and besides the fronds are often completely covered with dead leaves. Without sunlight, of course, they can be of no benefit to the plant, for they are unable to elaborate food materials. If one could find two plants of the same size growing side by side, it might be well to try the experiment of cutting off the old fronds from one of them in the fall. This might possibly make a difference in the size of the new fronds or in the time they came up, provided all other conditions were just the same.

Another variety with nearly the same range is to be looked for, especially in the mountains. It is the variety *dilatatum*, which has broadly ovate or triangular-ovate fronds that are usually tripinnate. The pinnules are lanceolate-oblong, the lowest often much elongated. The indusium is smooth and without glands, and the scales on the stipe have dark centers. A dwarf form of this has been named *dumetorum*. The variety *dilatatum* is less common than the preceding one, but it grows in much the same situations. The delicate cutting of its foliage and its size and gracefulness make it one of the most beautiful ferns we have. Closely related to it is one more variety that has rather large sori, with glandular indusia, that form two lines on the smaller pinnules or on the lobes of the

Nephrodium spinulosum dilatatum. (Reduced.)

Page 220.

larger ones. The fronds are tripinnate below, bipinnate above. The stipes, which are one-third to one-half the entire length, are clothed sparingly with pale-brown ovate scales. The lowest pinna often stands alone without another to balance it on the opposite side of the rachis. This has been called variety *fructuosum* on account of the numerous sori. So far it has been collected only in New York and Connecticut, but it may prove to be of much wider range.

The spinulose wood fern is a very easy species to cultivate. It thrives beautifully in the indoor fernery.

Boott's Shield-fern. 54.

Nephrodium Boottii.

(G. *Aspidium;* B. *Dryopteris.*)

Fronds one to two and one-half feet tall, elongated-lanceolate in outline, somewhat narrowed at the base, bipinnate. Lowest pinnæ tringular-ovate, the upper ones longer and narrower. Pinnules oblong-ovate, obtuse, the lower pinnatifid, the upper smaller and spinulose-serrate. Indusia minutely glandular. Scales on the stipe pale brown.

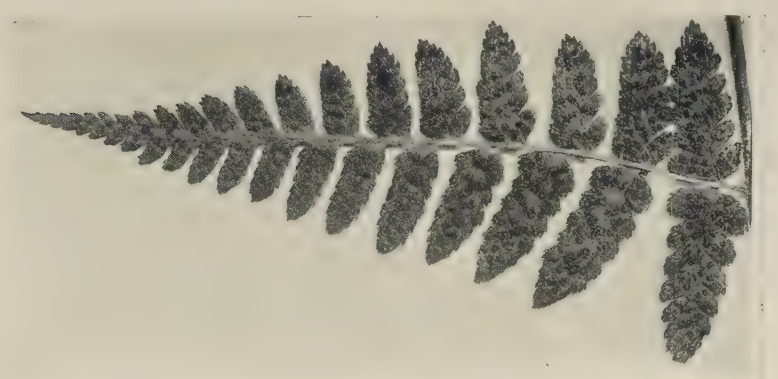
HIS beautiful fern was formerly regarded as a variety of *N. spinulosum,* but is now believed to be a distinct species. It is so clearly related to that fern and to the crested shield-fern that it has even been suggested that it might be a hybrid between the two. In support of this view it has been pointed out that it is rarely found except where they grow, and its spores are said to be abortive, appearing as if carbonized when seen under the microscope. However, it presents fewer

Boott's Shield-fern. × ½.

Page 222.

variations than we would expect if it were a hybrid, and few, if any, botanists hold this view at present.

In the woodland where we have found the two chain-ferns, the Massachusetts fern, a curious variety of the cinnamon-fern, and the two species most nearly related to Boott's shield-fern, we were so fortunate as to come across a small clump of it early in May. The young fronds had not fully expanded, but there was something so characteristic about the way they held themselves, and their rather narrow outline, that we at once suspected that this would prove to be a new addition to our local flora. And so it was, for a month later the place was revisited and some fine fronds were added to our herbarium. The six or seven



A Pinna of *N. Boottii multiflorum.* (Natural size.)

plants grew so close together that a twelve-inch flower-pot would have held them. There are four or five localities for it in the vicinity of Washington, so that northern Virginia is apparently the limit of its occurrence in the South.

The Crested and Marsh Shield-ferns.

Page 224.

The cutting of the pinnæ reminds one of the spinulose wood-fern, but in its habit and the outline of its fronds it is more like the crested shield-fern. These two species have erect fertile fronds that are much taller than the sterile ones, and, as we should expect, the pinnæ are twisted so as to be horizontal. In this way they receive the greatest amount of light from above, for they usually grow in dense woods or thickets.

Certain large forms of this species have been named variety *multiflorum*. The fronds are two and one-half to three feet tall. The two lowest pairs of pinnules on each pinna are pinnatifid, and have two or three pairs of sori on each segment. It is to be looked for where the type occurs.

Crested Shield-fern. 55.

Nephrodium cristatum.

(G. *Aspidium;* B. *Dryopteris.*)

Fronds linear-oblong or lanceolate, one to two feet long, pinnate. Pinnæ short, triangular-oblong, or the lowest nearly triangular, deeply pinnatifid into six to ten pairs of finely serrate or toothed segments. Sori large, as near the midveins as the margin. Indusia smooth.

ALONG the swampy borders of little streams that run through low woods we are apt to come across the erect fertile fronds of the crested shield-fern far overtopping the shorter sterile ones that spread out gracefully. Though not one of our largest ferns, it is one of the most handsome, and there is a certain stateliness and dignity about it that compels ad-

Crested Shield-fern. × ½.

Page 226.

miration. It is a fern one does not tire of whether we see it in its prime in July, or at the close of winter when the first warm days take us to the low woods to look for signs of spring. The thick, dark fronds are still fresh and beau-

Sori of the Crested Shield-fern. (Magnified.)

tiful, almost the only green things in the swampy woods at that time. We first found the plants shown in the illustration about ten years ago, and now we rarely enter the little woodland without seeing how they fare. The frond-tip showing the sori was picked from one of them late in June just before the spore-cases opened. The

thick, persistent indusia show beautifully, and are of the typical shield-fern shape. The sori are quite large, and they are very striking objects with their nearly black spore-cases covered partially by the white indusia. As the spores are shed the fruit-dots become brown, the color of the empty spore-cases, and the indusia nearly disappear. The fertile fronds do not survive the winter.

The illustration on page 224 will give an idea of where to look for the crested shield-fern. We always expect to find it in low woods in company with lady-ferns, cinnamon-ferns, skunk-cabbage, and stray plants of the marsh-fern. Later in the summer these spots may be partly overgrown with nettles and touch-me-nots and rich-weed (*Collinsonia*). The fern occurs as far south as Virginia and Arkansas, and westward to Idaho.

It will be noticed that the pinnæ of the tall fronds are all twisted horizontally, while the tips are curved over somewhat. This is done in order to secure the greatest possible amount of light upon the upper surface of the frond. Some years ago we had one or two plants of this fern growing close to the north side of a board fence so that the light reached them from one direction only. All the pinnæ faced outward at an angle of about forty-five degrees. Even a frond that came up facing the fence had the pinnæ twisted around in the same way. In this case the frond was practically reversed, except the stipe. When grown indoors, this fern, as might be expected, reaches out toward the light, with the pinnæ turned nearly parallel to the window.

Clinton's Shield-fern. × ⅓.

Page 229.

A variety of the crested shield-fern which is commoner northward, though it has been found in Virginia by one collector, is known as Clinton's shield-fern or *N. cristatum* var. *Clintonianum*. It is much larger, as a rule, than the ordinary form. The pinnæ are oblong-lanceolate, and four to six inches in length. There are eight to sixteen pairs of linear-oblong, obscurely serrate segments to each pinna. The sori are near the midvein. It is found with the typical form. It can be told from the next species by its having the pinnæ broadest at the base. The scales on the stalk are also not so large, and are without the very dark brown centers so characteristic of the next species.

Goldie's Fern. 58.

Nephrodium Goldieanum.

(G. *Aspidium;* B. *Dryopteris.* The specific name is often spelled *Goldianum.*)

Fronds two to five feet tall, broadly ovate, or ovate-oblong, nearly bipinnate. Pinnæ oblong-lanceolate, broadest at the middle; the divisions oblong-linear, slightly scythe-shaped, serrate with appressed teeth. Sori very near the midvein. Indusia large.

E were once told, as a great favor, where to look for six or eight plants of Goldie's shield-fern, and were further informed that "it is said that there are a couple more plants near a spring" in a certain woods several square miles in extent. It was not hard to find the spring, but we have been looking for those two plants for six or seven years. The other six were easily found, as they grew along a tiny stream flowing down a steep hill. The largest plant was nearly five feet tall,

Goldie's Fern. × ⅓.

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and its five or six bright green fronds arranged in a circle made it one of the most magnificent ferns we have ever seen. At the base the stipes were as thick as lead-pencils, and clothed with large brown scales with dark centers.

It is not an evergreen, though its thick pinnæ would lead one to expect it to be hardy enough to endure almost any amount of cold weather.

Goldie's Shield-fern.

Like most of the ferns related to it, Goldie's shield-fern prefers the wet places in the woods, though it rises superior to the lowly company of jack-in-the-pulpit, and skunk-cabbage, and all the rest. It is by no means a common fern, though it is said to be abundant in certain favored

spots. We have never seen any but the few plants mentioned, and four more twenty miles away.

The plant in the illustration, which was about three feet high, was dug up a day or two later by a man who happened along just as we were ready to photograph it. He thought it was a cinnamon-fern, and said he wanted to have it in his yard, and would come out again in a few days to get it. There was nothing to be said. To tell him that it was rare and should be left where it was would have invited the destruction of the others near it. It is needless to say that these have been transplanted to a spot far away from their home, to save them from a second visit when he finds that they are not cinnamon-ferns. Every lover of ferns should consider himself a committee of one to help protect our rarer species. The loss of such a plant is irreparable, and the ones that were transplanted are now of less value than before. In a way they have become cultivated plants, or at least in their present situation they are only "introduced." The wild things suffer so in the neighborhood of large cities that every society that has for its object the preservation of plants and animals deserves all encouragement. To those outside the pale all such efforts are foolishness, but in many cases their indifference is due to ignorance. It is for true nature lovers to educate them up to

> "that sweet mood when pleasure loves to pay
> Tribute to ease; and, of its joy secure,
> The heart luxuriates with indifferent things,
> Wasting its kindliness on stocks and stones,
> And on the vacant air."

Log-fern. × ⅓.

Page 234.

We have already seen that it may be distinguished from Clinton's shield-fern by the shape of the pinnæ, which are broadest at the middle.

The "log-fern" is a variety of Goldie's fern which was discovered in the Dismal Swamp of Virginia by Wm. Palmer, who named it variety *celsum*. The common name refers to its occurrence on decaying logs. It differs from the typical form "in its less herbaceous condition, more erect, narrow habit, the greater reduction of the lowermost pinnules, the more widely separated smaller pinnules, and less crowded apex." It will also be noticed that the lower pinnæ are quite long-stalked.

It closely resembles Clinton's fern in general appearance, but differs from it in having the basal pinnules of the lower pinnæ smaller than those nearer the middle of the pinnæ. All the basal pinnules of Clinton's fern are larger than those next above them. The log-fern has the characteristic large brown scales with very dark centers at the base of the stipe, while those of Clinton's fern are pale brown. Some botanists regard the log-fern as a form of Clinton's fern, but the scales on the stipe are almost good enough evidence, by themselves, to show that this is a form of *Goldieanum* and not of *cristatum*.

This variety should be looked for on logs wherever Goldie's fern is found. It has not been found growing in the soil.

Evergreen Wood-fern; Marginal Shield-fern. 57.

Nephrodium marginale.

(G. *Aspidium;* B. *Dryopteris.*)

Fronds one to three feet long, ovate-oblong, bipinnate. Pinnæ lanceolate, taper-pointed, slightly broadest above the base. Pinnules oblong or oblong scythe-shaped, crowded (or sometimes distant), obtuse or pointed, entire or crenate, or pinnatifid. Sori close to the margin.

HILE not so large and stately as Goldie's shield-fern, the evergreen wood-fern does not fall far behind, and it has the advantage of being comparatively abundant, so that it is admired by many who never see the former species. If we search on almost any rocky hillside in rich woods anywhere within our limits, we are very apt to see its large fronds growing in a circle around the stout, nearly erect rootstock. A characteristic feature of this fern is the dense covering of large, bright-brown scales on the rootstock and on the stipes near the base. They are well shown in the illustration. With this, and the sori placed close to the margin (page 51), and the peculiar bluish-green, almost leathery fronds to guide us, we can hardly make a mistake in naming this fern.

Sometimes we find on the rocks small plants that fruit when not more than four or five inches high, but where the soil is rich and deep they may reach the height of three feet. Often these large fronds, and at times the smaller ones, have the pinnules deeply pinnatifid, and two varieties, or, better, forms depending on this, have been de-

Marginal Shield-fern.

Page 237.

scribed. The variety *elegans* has ovate-lanceolate, pointed pinnules narrowed to a somewhat heart-shaped, obscurely stalked base, deeply pinnately lobed, and two or three times as long as usual. The fronds are not necessarily larger than usual. Variety *Traillæ* has very large fronds with all the pinnules pinnatifid. The pinna marked *a* in the illustration was the lowest one of a frond about intermediate between these two varieties. Still another form has the pinnules more or less pinnatifid and separated by spaces about their own width. It passes over into the form shown in the illustration. It might be well to call it *distans* for convenience in referring to it. After all, no name has any further value.

The evergreen shield-fern lasts through the winter, as its name indicates, but the fronds are bent over to the ground late in the fall because the stipes weaken at the base just as those of the spinulose shield-fern do. Both the sterile and fertile fronds, which are nearly the same size, are evergreen.

No excuse is needed to quote what Thoreau said of the wood-ferns as he saw them in midwinter. They are so beautiful, so hardy, that one cannot help wondering "what means this persistent vitality? Why were these spared when the brakes and Osmundas were stricken down? They stay as if to keep up the spirits of the cold-blooded frogs which have not yet gone into the mud, that the summer may die with decent and graceful moderation. Is not the water of the spring improved by their presence? They fall back and droop, here and there, like the plumes of depart-

The Marginal Shield-fern.

"In November days,
When vapours rolling down the valleys made
A lonely scene more lonesome."

Page 239.

ing summer, of the departing year. Even in them I feel an argument for immortality."

. . . . . .

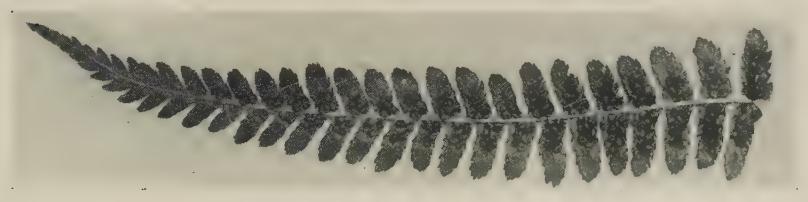
"Greenness at the end of the year, after the fall of the leaf, a hale old age. To my eye they are tall and noble as palm-groves, and always some forest nobleness seems to have its haunt under their umbrage. All that was immortal in the swamp herbage seems here crowded into smaller compass, the concentrated greenness of the swamp. How dear they must be to the chickadee and the rabbit! the cool, slowly retreating rear-guard of the swamp army."

The thick, woody rootstock, covered with the undecayed remains of stipes that date back many years, sometimes grows nearly erect, so that in Eaton's "Ferns of North America" the statement is made that it "comes nearer being a tree-fern than any other of our species, the caudex (rootstock), covered by the bases of fronds of previous seasons, sometimes resting on bare rocks for four or five inches without roots or fronds." This miniature trunk is often two or three inches in diameter, the rootstock proper being over half an inch through.

A curious form of the marginal shield-fern is distinguished by "the apex and tips of the lower pinnæ bearing tassel-like enlargements produced by the dividing of the rachis into two or more parts, these being again parted and these segments once or twice cleft, thus forming a series of short, overlapping, crowded, and somewhat spreading parts." We have seen no specimens of this form, which has been called *Davenportii* in honor of the veteran fern-

student, but from the description it appears to be like so many other so-called "crested" forms. They are merely extreme cases of forking of a peculiar type. This fern should be looked for wherever the ordinary form of the species grows.

The marginal shield-fern is found from Nova Scotia to Georgia and Alabama, and westward. A closely related species occurs abundantly in Europe, but in this hemisphere it is confined to the far north, except in the west, where it is found in Arizona and California. It is to be looked for in Nova Scotia and Newfoundland. It is the



Pinna of the Male Fern. (Natural size.)

male fern, *Nephrodium filix-mas*. The fronds are lanceolate, tapering from the base to the apex. The pinnules are oblong, very obtuse, serrate, or the larger ones pinnately incised. The sori are near the midveins, and usually on the lower half or two-thirds of the pinnule. The rachis is more or less chaffy. The fronds are thinner than those of the marginal shield-fern, and are not evergreen. It is the only fern used in medicine, being one of the officinal remedies in the German and Austrian pharmacopœias. Wossidlo's detailed drawings of it are being copied, as an illustration of a typical fern, in all the more recent Ger-

man text-books of botany, and even in the American ones, although the marginal shield-fern would seem to be better suited for the purpose in this country.

Crested Marginal Fern. 56.

Nephrodium cristatum × *marginale.*

(B. *Dryopteris cristata* × *marginalis.*)

Fertile fronds one and one-half to two and one-half feet tall; sterile fronds one-half to two-thirds as large. Frond elliptic-lanceolate, narrowing both ways, the lower third usually with triangular-ovate, obtuse pinnæ as in *N. cristatum,* the upper two-thirds more like *N. marginale* in outline, with long-tapering, deltoid-lanceolate or lanceolate pinnæ, and narrowing gradually to the acuminate apex. Pinnæ variable, nearly sessile or stalked, distant, or approximate, alternate or opposite, narrowing gradually to the acuminate apex, deeply pinnatifid. Sori nearer the margins than in *N. cristatum.*

HIS long description is barely sufficient to point out the characteristics of this hybrid between two rather closely related ferns. It occurs on the borders of swamps with the crested and marginal shield-ferns, near the bases of rocky hills where the latter is found. It can be distinguished from the crested shield-fern by having the central crown of the rootstock surrounded by fronds, while in the latter the crown of the horizontal rootstock extends beyond the fronds, much as in the lady-fern (page 37). The outline of the upper two-thirds of the frond is broader, and the frond and pinnæ are more taper-pointed than in the crested shield-fern. The young plants and sterile fronds are much like this species.

A striking peculiarity is the tendency of the pinnæ to grow very irregularly. The shape of the fronds, and its occurrence only where the other two ferns are found, led

Crested Marginal Fern. × ½.

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to the suspicion that it was a hybrid. The small number of spores produced also argues in favor of this view. There is now, however, no possibility of any controversy over the matter, for Miss Slosson succeeded in producing the hybrid by experiments like those described before (page 135).

We have ventured to suggest the name crested marginal fern to indicate its parentage. Apparently no other common name has been given to it.

Christmas Fern. 52.

Polystichum acrostichoides.

(G. *Aspidium.*)

Fronds one to three feet high, lanceolate, pinnate. Pinnæ linear-lanceolate, somewhat scythe-shaped, auricled on the upper side of the base, serrulate with bristly teeth. The fertile upper pinnæ contracted. Sori close together and near the midrib, soon confluent.

HE Christmas fern is one that would soon be doomed to destruction were it not for its great abundance and its hardy nature that enable it to withstand the onslaughts of the men who collect it and the spinulose wood-fern for the florists. Its common name is most aptly chosen, for the thick, almost leathery, dark glossy green fronds play a prominent part in holiday decorations in winter. A large plant of it is one of our most attractive ferns, its beauty depending on its rich color and the way it holds itself, or its "habit," as the botanist says, rather than on the cutting of its fronds. The plant shown in the illustration was an unusually fine one, nearly three feet tall. It was growing in rich soil in rather open woods. The fern seems to prefer rocky slopes in the woods, and

Christmas-fern.

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the damp soil along the banks of little shaded streams. The sterile fronds are spreading, or they may even hang

Tip of Fertile Frond. (Natural size.)

downward, when the plant grows on steep banks, while the much taller fertile ones are erect.

It is one of the earliest ferns to come up in the woods, and

Christmas-fern.

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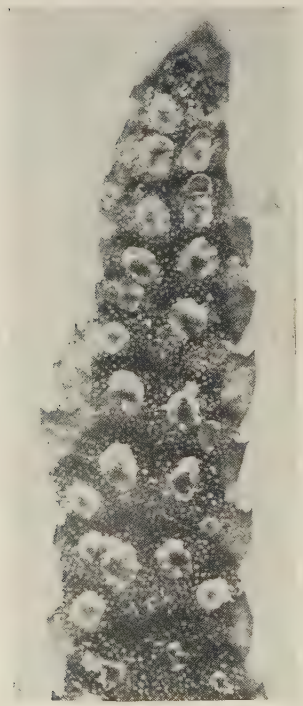
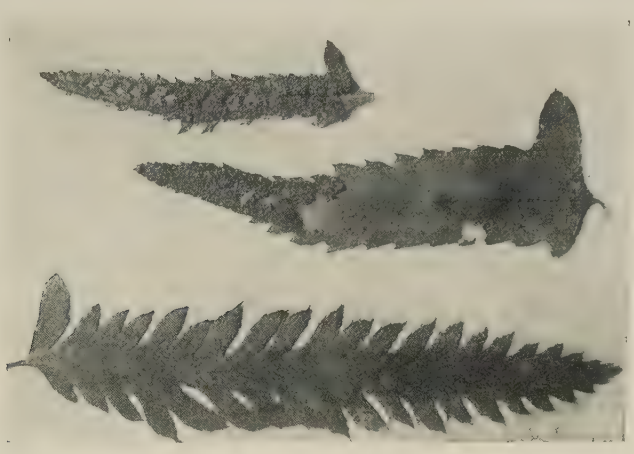
the grayish-green young fronds have a peculiar backward bend that is quite characteristic. When they are just beginning to appear above ground the young sori can plainly be seen forming one or two rows along each side of the midrib. They are covered with large, circular indusia attached by the center (page 51). Later the indusia are pushed aside and wither, and the sori form a mass of brown spore-cases covering the under side of the pinna, reminding one of the tropical genus *Acrostichum*, in which the sporangia are spread over the whole surface of the pinna. *Acrostichoides* means "like *Acrostichum*." The generic name is derived from two Greek words meaning "many rows," although it has no very obvious application to this fern. The sori are certainly not in many rows, unless we count across the pinna.



Old Sori of the Christmas Fern. ×5½.

Only the upper pinnæ are fertile, and they can be told at a glance, for they are much shorter and narrower than the sterile ones. Sometimes only two or three pairs of pinnæ bear sporangia, and again more than half the frond may be fertile. Specimens can be found with the tip sterile for about an inch and then come a few pairs of contracted fertile pinnæ. Again, we find fronds with the upper pinnæ entirely fertile as usual, while the tips of the

lower ones are contracted and bear a few fruit-dots. In this latter form the edges of the pinnæ are more incised than usual, so that it has been called variety *incisum*. The illustration shows an upper and a lower pinna of a fertile frond and a deeply incised sterile pinna. This variety is to be looked for wherever the typical form is found, and it is more apt to be found late in the summer. The Christmas fern often sends up



Var. *incisum*. (Natural size.)

second-growth fronds in August, especially if it is very rainy in July, and many of these fronds belong to this variety—or form, as it is best to call it. The fronds of early summer shed their spores by July, and those of the second growth in September.

Another form of the Christmas fern has the pinnæ "beautifully crisped and ruffled," apparently from a "superabundance of tissue." It is to be looked for in rich woods. It has been called variety *crispum*.

Besides these forms one can easily find a great many

variations in the outline of the pinnæ, from extremely blunt to sharp-pointed tips, and the pinnæ may be straight or curved, nearly entire or deeply serrate. The search for such abnormal forms adds greatly to the interest of a trip through the woods when one has become perfectly familiar with the ordinary forms of the ferns.

The fronds of the Christmas fern, like those of the evergreen species of Nephrodium, fall over to the ground in the autumn, not because they are beaten down by storms or crushed by the forest leaves, but on account of the decay of the tissues near the base of the stalk. The fibrovascular bundles remain intact, but, as we have already said, it is not likely that these fronds are of any benefit to the plant in the spring. The illustration on the opposite page shows a clump of prostrate fronds on a sloping roadside bank as they appeared in February.

A poet with more enthusiasm than accuracy has described the Christmas fern in the following lines:

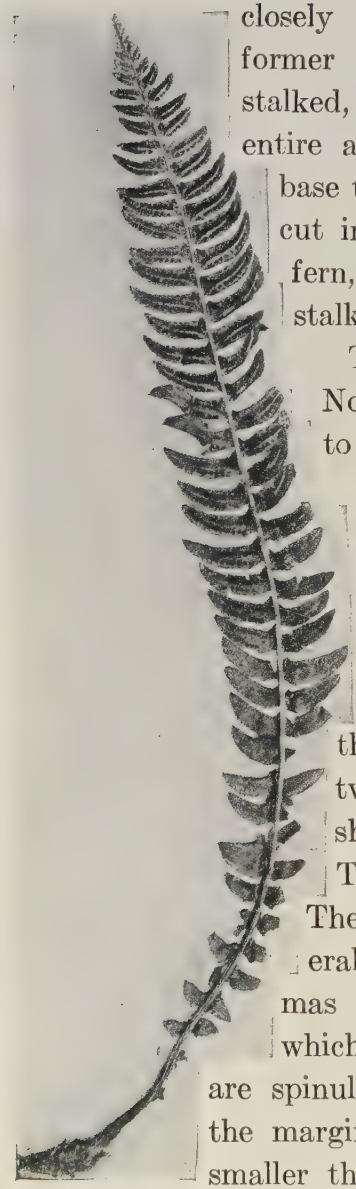
"When frost has clad the dripping cliffs
With fluted columns, crystal clear,
And, million-flaked, the feathery snow
Has shrouded close the dying year;
Beside the rock, where'er we turn,
Behold there waves the Christmas fern.

"No shivering frond that shuns the blast
Sways on its slender chaffy stem;
Full-veined and lusty green it stands,
Of all the wintry woods the gem.
Our spirits rise when we discern
The pennons of the Christmas fern."

Small specimens of the Christmas fern are sometimes mistaken for the polypody, but they are quite unlike when

The Christmas-fern in Winter.

Page 251.



Holly-fern.

closely examined. The pinnæ of the former are incised, auricled, and short-stalked, while those of the latter are entire and are attached by the entire base to the rachis, and are not always cut in to the rachis. The Christmas fern, unlike the polypody, has a scaly stalk.

The Christmas fern is found from Nova Scotia and New Brunswick to Wisconsin, and south to the Gulf states.

A closely related species, known as the holly-fern (*P. Lonchitis*), is found in Nova Scotia, southern Ontario, and far to the north and west. It is smaller than the Christmas fern (nine to twenty inches long), is very short-stalked and quite rigid. The fronds are linear-lanceolate. The pinnæ are of the same general shape as those of the Christmas fern, except the lowest ones, which are triangular. The edges are spinulose-toothed. The sori are near the margin, and the fertile pinnæ are no smaller than the sterile ones.

The fern is evergreen. Its common

Braun's Holly-fern. × $\frac{1}{3}$.

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name is said to refer to the resemblance of the pinnæ to holly-leaves, but this is not apparent from the illustration, which is made from a European specimen.

Braun's Holly-fern. 45.

Polystichum Braunii.

(G. *Aspidium aculeatum Braunii.*)

Fronds one to two feet high, oblong-lanceolate, with a tapering base, bipinnate. Pinnæ oblong-lanceolate, the lowest reduced in size and obtuse.

Sori of Braun's Holly-fern. ×5½.

Pinnules ovate or oblong, truncate and almost rectangular at the base, sharply toothed, beset with soft, chaffy hairs.

IN the mountains of Pennsylvania, Vermont, New Hampshire, and Maine, and far to the north we may look for Braun's holly-fern, the most beautiful of our species of *Polystichum*. The cutting of the fronds, their rich, glossy green, and their stately habit, make it a fern which is hard to surpass.

The fronds may begin to bear a few fruit-dots when only five or six inches in length, but they are not heavily fruited until they become much larger. The sori do not cover the surface of the pinna as in our other two species of *Polystichum*, but are more scattered. The illustration, made from a frond collected in August, shows the sori with their circular indusia. Most of the spore-cases were still green and translucent.

Bulblet Bladder-fern; Bulbiferous Bladder-fern. 32.

Cystopteris bulbifera.

(B. *Filix bulbifera.*)

Fronds one to three feet long, lanceolate, elongate, bipinnate, with lanceolate-oblong, pointed pinnæ. Pinnules toothed or pinnatifid. Rachis and pinnæ often bearing bulblets beneath.

SOMETIMES in shaded ravines we come across patches of this fern with its fronds hanging down over the moist rocks as if trying to hide their bareness. The delicate, lace-like curtain formed of the slender, intertwining fronds is one of the most beautiful sights in the woods. There is an airiness, a gracefulness about the pose of the fronds, and their color is such a delicate, fresh green that it has few rivals among

Bulbiferous Bladder-fern. × $\frac{1}{3}$.
a, young plant from a bulb.

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our ferns. It is a worthy member of that chosen company dwelling in moist limestone ravines. We may expect rare

Development of Young Plants from Bulblets. ×3.

ferns even on an exposed limestone cliff, but where the rock is shaded and dripping with moisture it seems as if Nature were trying to outdo herself. The rocks seem to

retain some of the life of past ages, and the shells slowly formed in the depths of the sea are now wasted away in supporting a luxuriant vegetation.

Along the under side of the rachis and pinnæ there are formed curious bulblets that fall off and soon produce new plants. Each bulb is formed of two or three little bits of fleshy, green tissue (scales) joined at the base. A week or two after a bulb falls upon moist soil a couple of slender roots spring from between the scales and penetrate the soil. Then a tiny frond starts to uncoil from the heart of the bulb, and after it come larger and larger ones until it has become a good-sized plant. As these fronds are formed the rootstock pushes out from the bulb, growing longer and thicker as the fern gains strength. In the illustration are shown two bulblets, just as they fall from the plant, and various stages in the development of the young ferns, all enlarged three times. It is interesting to see how the rootstock arises from the bulblet.

The fertile fronds are taller than the sterile ones. Usually their pinnæ are far apart, and the frond has a curious, attenuated appearance as if the rachis had been stretched. Specimens three feet in length are not uncommon, and one may occasionally find a frond four feet long. On account of its peculiar outline a fertile frond of this fern is not apt to be mistaken for any other species, but a sterile frond without bulblets is not always easy to distinguish. It most closely resembles the fragile bladder-fern, but its stalks are more apt to be reddish, and the two bundles are about twice as long as broad, instead of nearly round

as in that species. The pinnæ of the fragile bladder-fern are "decurrent," that is, they "run down" the rachis, being connected by a narrow wing or ridge that joins the base to the pinnæ next above and below.

The bulbiferous bladder-fern is found from Newfoundland to North Carolina, Alabama, and westward.

Brittle or Fragile Bladder-fern. 27.

Cystopteris fragilis.

(B. *Filix fragilis.*)

Fronds oblong-lanceolate, six to eighteen inches long, twice or thrice pinnate. Pinnæ and pinnules ovate or lanceolate in outline. Pinnules cut-toothed or irregularly pinnatifid, mostly acute, decurrent on the winged rachis.

ONE of the standing puzzles in the world of fern-students is to know what to do with the fragile bladder-fern. It is so variable and the extreme forms are so unlike one another that, judging from them alone, we would conclude that each was a distinct species. Yet no dividing lines can be drawn, because the forms run into one another by imperceptible gradations. We cannot even make geographical species and call the plants from Europe and eastern and western America by different names, for we may find growing almost side by side specimens that are more unlike than fronds from California and Russia may be. Apparently there is no way to escape this confusion. The illustration gives an idea of a few of the forms, although there are differences in texture which escape the camera. Even the rootstocks vary, some being

Fragile Bladder-fern. × $\frac{2}{3}$.

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slender creeping ones and others short and densely covered with the bases of the stipes of several years previous.

The situation in which the plants are found seems to have as much influence as anything else in causing variations. On moist, shaded rocks the smaller, less divided, filmy forms occur. In rocky woods they are usually larger, more divided, and rather thicker in texture. These vary more or less among themselves. Some large, coarse fronds with the pinnæ and pinnules rather more pointed than usual, and different in their entire aspect, were seen on a grassy bank with a northeastern exposure. On dry rocks, or on dry soil as we have found it, is still another form that has been named variety *magnasora* on account of its large sori.

Perhaps the most characteristic situation for it is on shaded cliffs. The delicate fronds are among the first to appear in the spring, and the spores ripen early and are scattered to the winds. Both of the bladder-ferns have the sori covered with very delicate indusia that soon wither away, and one must be on the lookout for them when the fronds first uncoil. The common and generic names refer to these sac-like or bladder-like indusia. An illustration from a photograph of the sori of this species is given on page 52. The indusia are generally more pointed at the free end than the ones there shown.

Beginners often confuse the fragile bladder-fern and the obtuse Woodsia. The latter has more or less glandular-pubescent fronds, and the stalks are clothed with scattered, pale-brown scales when young. Also, the two bundles in

The Mountain Bladder-fern.

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the stipe of the Woodsia unite very soon, and they are to be seen only at the very base of large stipes. On the other hand the stipes of the smallest fronds of the bladder-fern contain two fibrovascular bundles. One frond only an inch and a quarter high had two bundles in the stipe.

Mountain Bladder-fern.

Cystopteris montana.

(B. *Filix montana.*)

Fronds six to fifteen inches long, deltoid-ovate, tri- to quadripinnate, about as long as broad. Lowest pinnæ deltoid-lanceolate, much larger than the upper. Segments deeply divided into oblong lobes, deeply toothed. Sori numerous; indusia acute, soon withering.

ONE of our rarest ferns, which is also found in Europe and Asia, is the mountain bladder-fern. It has been found from Labrador and Quebec to British Columbia and Alaska, and south to the northern shore of Lake Superior.

A careless collector might mistake small fronds of this for the oak-fern, but the resemblance between the two species is extremely superficial, depending only on a slight similarity of outline and cutting. Indeed, there is no other fern within our limits that should be mistaken for the mountain bladder-fern.

Like the two related ferns it grows on rocks, which it covers by means of its long, slender, creeping rootstocks. It must be a beautiful sight, for a single frond, apart from such surroundings, is most attractive.

The illustration is from a European specimen.

Sensitive Fern. (Reduced.)

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Sensitive Fern. 38.

Onoclea sensibilis.

Fronds one to three feet high, triangular-ovate, pinnatifid into a few oblong-lanceolate, sinuately-lobed, nearly entire, or sometimes pinnatifid segments. Veins reticulated. The fertile fronds shorter, closely bipinnate, with the pinnules rolled up into berry-like bodies enclosing the spores.

N certain geological deposits known as Miocene limestone, Newberry found some fossil ferns which he believed to be a variety of the sensitive fern. If that be true, this fern is old in years, although only a young upstart in geological time; but there is considerable uncertainty about the correctness of that view. Lesquereux doubted the identity of the two on account of the thick, leathery character of the fossil frond, while the sensitive fern is of a comparatively thin texture. Dawson, however, says that the fossil fern is undoubtedly the sensitive fern. When two such geologists disagree it seems to be time for the botanist to decide, though hesitatingly. D. C. Eaton wrote: "As similar venation and not very dissimilar fronds are seen in *Woodwardia* and *Pteris*, one may perhaps doubt the absolute certainty of the identification." It must be remembered that fossils are, at best, but imperfect specimens, for we have simply fragments of the original plants, and it is not strange that there should be a difference of opinion about this fern.

The name sensitive fern seems a very inappropriate one to apply to such a large, coarse-looking plant, and

there is some doubt about its origin. It has been suggested that the name was given because the fronds wither so soon after being cut, or because they are killed by the earliest frosts.

The home of the sensitive fern is in wet meadows and open thickets, and also in damp woods where it is not too shady. In such places it may form dense clumps, for by its creeping rhizome, that sends up a number of fronds each season, it is enabled to down many another plant in the struggle for existence. In the spring the sterile fronds come up, and in July the fertile ones appear. The sunnier the situation the more of the latter are produced, and in the woods the fern rarely fruits. In the densest shade the fronds are often small and the margins of the segments are not even wavy, so that it appears very different from the coarse plant with the segments deeply lobed, or even pinnatifid, that we find growing in the sun. For all that, it is not what one would call a variable species, and few ferns are easier to identify. It resembles the narrow-leaved chain-fern more nearly than any other fern, and the points of difference were mentioned when that species was taken up.

The fertile fronds are of especial interest because they combine the greatest economy of material with the maximum of protection for the growing spores. To use a crude simile, most ferns hold the sori in the open hand, but the sensitive fern grasps them tightly in the clenched fist. The little berry-like divisions (see page 52) of the frond represent pinnules bearing a number of fruit-dots around

Onoclea sensibilis obtusilobata. (Reduced.)

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which they are closely rolled. At maturity the little pods are burst open, but many of the spores are probably held until the following summer, when the fronds are at last beaten to the ground.

The so-called variety *obtusilobata* is a form, intermediate between the ordinary sterile and fertile fronds, that is apparently never produced except when the plant has been cut down, or injured in some other way, early in the summer, and is thus compelled to send up new fronds in order to elaborate food for its present needs, and also to lay up a supply of it in the rootstock for the next year. The plant had been preparing the fertile fronds, but all its arrangements are upset, and it is compelled to hurry them along to do the work of the lost sterile ones. Besides, the food-supply in the rootstock has been nearly exhausted in sending up the first fronds, so we now see a lot of strange, stunted, half-fertile ones—the variety *obtusilobata*. As we see from the illustration, these may vary from a large, much-lobed, sterile frond, quite unlike the ordinary ones in appearance, to a low fertile frond with spreading pinnæ, the divisions of which are smaller and of a lighter green than usual. Between these we may find a whole series with some of the pinnæ sterile and others fertile, or they may have the margins of the lobes partly bent back over the indusia, as shown on page 53. These indusia are but a mockery, for there are no spore-cases under them—nothing for them to protect. A series of all these intermediate forms, and others too numerous to mention, is most interesting and instructive, showing as they do the essential

unity of the two forms of fronds that are so unlike in appearance.

The sensitive fern is found in Europe, in Japan, and everywhere in the United States east of the Mississippi, as well as in some states to the west of that river.

Ostrich-fern. 39.

Struthiopteris Germanica.

(G. *Onoclea Struthiopteris;* B. *Matteuccia Struthiopteris.*)
Fronds two to seven feet long, pinnate, with many linear-lanceolate, pinnatifid pinnæ. Veins free, not forked. Fertile fronds shorter, pinnate, with pod-like pinnæ.

DURING the first summer of our botanizing experience the ostrich-fern was pointed out by a more experienced friend, but for some reason or other no specimens of it were saved. But that characteristic tip of the sterile frond could not soon be forgotten, and it was like greeting an old friend when we stumbled upon a little colony of it in a mass of nettles growing close to a river in alluvial soil, a mixture of sand and scales of mica deposited when in flood. For a time it was thought that these plants marked the southern limit of the species, but Wm. Palmer has found it near Washington, fifty miles farther south. These plants produce fertile fronds but rarely, and one colony of about forty plants (see

Ostrich-fern. Sterile, fertile, and "*obtusilobata*" fronds. (Reduced.)

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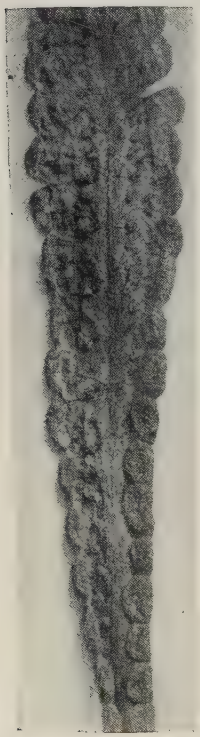
illustration page 13), many of which are over three feet high, has been entirely sterile for at least two years. But in Pennsylvania and the states to the north, where they

Ostrich-fern. Tip of Frond.

reach the height of six or seven feet, it produces numerous fertile fronds. The fertile fronds in a way resemble those of the sensitive fern, for the pinnæ are much contracted and the leafy part is tightly rolled around the fruit-dots (see page 53). They come up, in midsummer, in the center of the circle of much taller sterile fronds. Like those of the sensitive fern they are very dark green or almost black. They burst open irregularly as the spores mature.

When the first fronds are injured or destroyed early in the summer, those of the second growth are apt to

be partly fertile. We may refer to these as the "obtusilobata" form from its resemblance to the same form of the sensitive fern. The frond at the left of the illustration on page 270 belongs to this form. The upper pinnæ are small and narrow, and instead of being deeply pinnatifid are merely coarsely serrate. Towards the middle of the frond the pinnæ have more rounded teeth, while the edges show a tendency to be revolute. At the same time tiny, scattered indusia appear on the veins. Many of the pinnæ at the middle of the frond have their tips like those higher up, but at the base they are narrow and contracted like those of the usual fertile fronds. The lowermost ones are like small fertile pinnæ, being entirely rolled up, yet none that we have examined have borne any sporangia.



Part of pinna of "*obtusilobata*" form. ×4. Reprinted from The Plant World.

The underground portions of the ostrich-fern are of much interest. The fronds come up in a crown from the erect rootstock, which is thickly covered with the bases of old stipes and has a cluster of immature fronds at the upper end. From this rootstock there spring underground "runners" that are long and slender, and often extend three or four feet from the parent plant. Erect rootstocks with crowns of fronds are produced along this runner, that in timedies and lets the new plants lead an independent existence. No other of our ferns possesses

just such an arrangement, and few, if any, have adopted a better means of spreading their kind.

The common name has been given to the fern from the resemblance of the sterile fronds to ostrich-plumes. *Struthiopteris* is the Greek for ostrich-fern.

Several common ferns somewhat resemble the ostrich-fern. The cinnamon-fern and the interrupted fern can be distinguished with perfect certainty by examining the stem, for they have each a single, curved fibrovascular bundle of a very characteristic shape. The silvery spleenwort has a hairy stalk, and the pinnæ are also somewhat clothed with hairs. Its stalk is not so deeply grooved in front and is less flattened on the sides. The rachis of the ostrich-fern is narrowly winged on each side of the groove in front. The lower pinnæ of the ostrich-fern are very much shorter than those above, while the lower pinnæ of the spleenwort are nearly as long as the middle ones. There are many other points of difference between these four ferns, but enough has been said to enable any one to tell them apart. To one who is familiar with them they look entirely unlike.

Rusty Woodsia. 24.

Woodsia Ilvensis.

Fronds three to ten inches high, oblong-lanceolate, pinnate, smooth above, thickly clothed beneath, as well as on the stalk, with chaffy scales that are whitish when young, but soon turn rusty brown. Pinnæ oblong, obtuse, pinnatifid, with crowded, oblong, obtuse, obscurely crenate lobes.

HIS little fern loves to grow in dense tufts on the top of some rocky precipice, or scattered in little groups along the crevices in its face. It is so well adapted to living in dry situations that it

does not mind the effects of the blazing sun even in midsummer. As explained in connection with the lip-fern, the covering of scales on the under side of the frond, where the breathing-pores are situated, prevents the moisture in the plant from evaporating too rapidly. In May, when the fronds uncoil, the scales are very pale, or even white, but they soon turn to the color that has given the fern its common name.

Rusty Woodsia. $\times\frac{2}{3}$.

The habit the rusty Woodsia has of growing packed together in dense tufts on the top of some nearly bare rock is also a protective device. The mass of matted roots and rootstocks serves to retain moisture, and the scores of old stipe bases make a very efficient trap for particles of soil that may be brought to the plants in windy weather.

About an inch above its base the stipe is jointed. At this point, which is marked by a slight thickening, the stipe

breaks off when the frond is dead. There seems to be some connection between this and the tufted habit of the plant. If jointed at the base, the tuft of plants would be reduced to a mass of rootstocks and roots in the winter, and the soil surrounding them would be easily washed away.

Sori of Rusty Woodsia. ×5½.

If there were no definite place for them to break off, the old fronds might crowd the newer ones too much. It would be of no advantage for them to shed their pinnæ as the maidenhair spleenwort does, for the bare stalks would remain and hinder the unfolding of the new fronds.

The hairy lip-fern grows in similar situations, and it is sometimes mistaken for the rusty Woodsia, but a glance at the stalks is sufficient to distinguish them. Those of the Woodsia have the characteristic joints, and they are

chaffy, that is, covered with thin scales. They are brown near the base, shading to green higher up, and are flattened and grooved in front. The stalk of the lip-fern is dark chestnut-brown and is covered with hairs that appear jointed when seen through a lens. It is without grooves. It readily pulls away from the rootstock, bringing with it a few dark-brown scales.

The sori of this and of the next two species are provided with indusia that are attached beneath the sporangia and are split into long, narrow segments which are curled over the sporangia. A number of sori are shown in the illustration, but they are partly obscured by the scales and hairs on the pinnæ.

The rusty Woodsia is found from Labrador to Alaska, and southward to North Carolina, Kentucky, and Minnesota. It occurs also in Greenland and in Europe.

Northern or Alpine Woodsia. 23.

Woodsia hyperborea.

(B. *W. alpina.*)

Fronds two to six inches long, narrowly oblong-lanceolate, pinnate. Pinnæ triangular-ovate, obtuse, pinnately divided into a few nearly entire lobes, sparingly hairy. Stalk slightly hairy.

N the mountains of northern New York, Vermont, and Maine, and in British America one may be so fortunate as to come across this little fern, that has a wide range in northern regions but is never abundant. More than once it has been collected as *Woodsia glabella*, and this, perhaps, has something

to do with its being so seldom reported by botanists. Indeed, the first specimens known to have been collected in America were given that name by C. H. Peck, who discovered them in the Adirondacks. It is also mistaken for smooth forms of the rusty Woodsia, the two species being quite similar in their general outline. According to Eaton

Northern Woodsia.

the alpine Woodsia is "tenderer in texture, . . . narrower in outline, and has shorter, more obtuse, and less divided pinnæ" than the rusty Woodsia.

The specimens of alpine Woodsia that were examined when the analytical key was being prepared did not have any grooves in the stalks. This and the hairy instead of

scaly stalk will serve to distinguish it from the rusty Woodsia. The stalk of the alpine Woodsia is black at the base, shading to brown, and finally yellowish green above. The smooth Woodsia has a grooved stalk which is green or yellowish green except at the extreme base, where it is dark brown or black. The pinnæ and stalks of the smooth Woodsia are without the hairs that are found on the alpine Woodsia, but below the joint in the stipe there are a few scattered scales similar to those on the latter species.

The joint in the stipe is marked by a dark-green ring. Eaton states that there is a "delicate funnel-shaped extension of the fibrovascular bundle" extending to the surface of the stipe at this point.

Smooth Woodsia. 22.

Woodsia glabella.

Fronds two to five inches high, very delicate, linear, pinnate. Pinnæ roundish-ovate, the lower ones rather remote, obtuse, crenately lobed.

OME of our most fragile, delicate-looking ferns are among the hardiest and can live in the coldest climates. The green spleenwort, the slender cliff-brake, and the northern and smooth Woodsias are among the ones that may be mentioned. The last of these species is closely related to the northern Woodsia and has about the same geographical range in America. It occurs also in Greenland and in northern Europe. Although not so rare as the other species, it is by no means a common fern. It is noteworthy that the four species mentioned above, and other northern ferns besides,

live on moist rocks or even where the spray of waterfalls reaches them. On the contrary, the small spleenworts and other ferns that grow in dry exposed situations have a more southern range. Perhaps this is too sweeping a generalization, yet there is some truth in it, and at some future time we may see the connection between these facts.

Smooth Woodsia.

The differences between the smooth and the alpine Woodsias were pointed out when the latter species was discussed. The absence of scales on the frond and stipe (above the joint) is one of the surest means of identification. It is commonly stated in the manuals that *Woodsia glabella* is "smooth throughout," but this is incorrect. In his "Ferns of North America" Eaton pointed out what any one can see for himself, that there are a few chaffy scales on the stipe below the joint. Nearly every species of fern has such scales on the stipe when they are young, though they may fall off as the fronds develop. This is especially true of ferns with short, tufted rootstocks that have ready the young fronds for a year or two ahead. The scales serve as a protective covering, and aid in preventing too rapid alternations of freezing and thawing which would greatly injure the plant.

Obtuse Woodsia. 25.

Woodsia obtusa.

Fronds six to twenty inches high, broadly lanceolate, minutely glandular-hairy, pinnate. Pinnæ rather distant, triangular-ovate or oblong, deeply pinnatifid. Segments oblong, obtuse, crenately toothed, the lower ones pinnatifid.

THE obtuse Woodsia is more common than the other species of the genus within our limits, and it has a more extended range on this continent. It occurs as far north as Nova Scotia, and southward to Georgia, Alabama, and Texas. It grows on rocks and old stone walls in shady situations, but is at its best in the loose rocky soil at the base of cliffs. In such situations plants with fronds fifteen or even twenty inches high may be found. Such large ones are generally heavily fruited, while the shorter ones on the same plant are quite sterile or nearly so. When forced to grow on dry sunny rocks the mature fronds may be only five or six inches high, but they are well provided with fruit-dots. These are never very large, and one does not see their true beauty without the aid of a lens. Our other species of Woodsia have indusia that are fastened beneath the spore-cases, and are split into numerous slender segments that fold over them.

The Obtuse Woodsia.

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The indusia of the obtuse Woodsia are attached in the same way and completely enfold the sori, but they are soon split into five or six broad, jagged segments that spread around "in star shape, when the sorus considerably resembles a small green flower," as W. N. Clute puts it. In a comparatively short time the indusia shrivel up and are hidden by the growing spore-cases. This proved to be one of the most difficult ferns to photograph satisfactorily, for when the indusia were in the proper condition, they and the green sporangia were nearly the same color as the pale fronds. The illustration on page 54 was obtained from a herbarium specimen in which there was more contrast in color.

The obtuse Woodsia is not a very attractive fern in midsummer, for the fronds become yellowish and much blotched with white. It appears at its best in June when the fronds are fresh and bright green. In New England it is said to be a half-evergreen, and in Maryland the smaller fronds survive the winter. Indeed, it seems to grow a little on every warm day, for one can find partly developed fronds throughout most of the winter. In spite of this eagerness to grow we have never succeeded in keeping it alive in an indoor fernery, though others may have done so.

We have already told how it may be distinguished from the fragile bladder-fern with which it is often confused. The latter has smooth fronds, while those of the Woodsia are more or less glandular-hairy. The form which has been named *glandulosa* is simply a smaller and more glandular form.

The Obtuse Woodsia. (Reduced.)

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Oregon Woodsia.

Woodsia Oregana.

Fronds two to eight inches high, smooth, elliptical-lanceolate, pinnate, the fertile ones tallest. Pinnæ triangular-oblong, obtuse, pinnatifid. Segments oblong or ovate, obtuse, finely toothed, and in larger fronds incised. Indusia very small, divided almost to the center into a few necklace-like, jointed cilia or hairs. Stipes smooth.

THE Oregon Woodsia reaches its eastern limits in Wisconsin, northern Michigan, and Nebraska. It also occurs to the south and west.

Like the obtuse Woodsia, this fern has no joint near the base of the stipe, but it differs in being smooth, in having the indusium split into very short, thread-like lobes, and in not being so much divided, as well as in other minor points.

The Oregon Woodsia. (Reduced.)

The next species is similar to it in general appearance, but it has the stalk and under surface of the frond covered with minute flattened hairs and glands, and the segments of the indusium are not just the same, as stated in the descriptions.

The illustration is from a specimen in the herbarium of Capt. John Donnell Smith.

Rock-loving Woodsia.

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Rock-loving Woodsia.

Woodsia scopulina.

Fronds six to fifteen inches long, lanceolate, pinnate, tapering from the middle to both ends. Pinnæ numerous, oblong-ovate, pinnatifid into ten to sixteen oblong, toothed segments. Indusium hidden beneath the spore-cases, deeply cleft into narrow segments ending in jointed hairs. Stalks and lower surface of frond covered with minute hairs and stalked glands.

WE have already shown how this species may be distinguished from the Oregon Woodsia. It can be told from the obtuse Woodsia by the character of the lobes of the indusium and by being less divided.

This fern has been found in Michigan and western Ontario, and from there to British Columbia and south to Arizona and California.

The illustration is from a specimen in the herbarium of Capt. John Donnell Smith.

Hay-scented Fern. 8.

Dicksonia pilosiuscula.

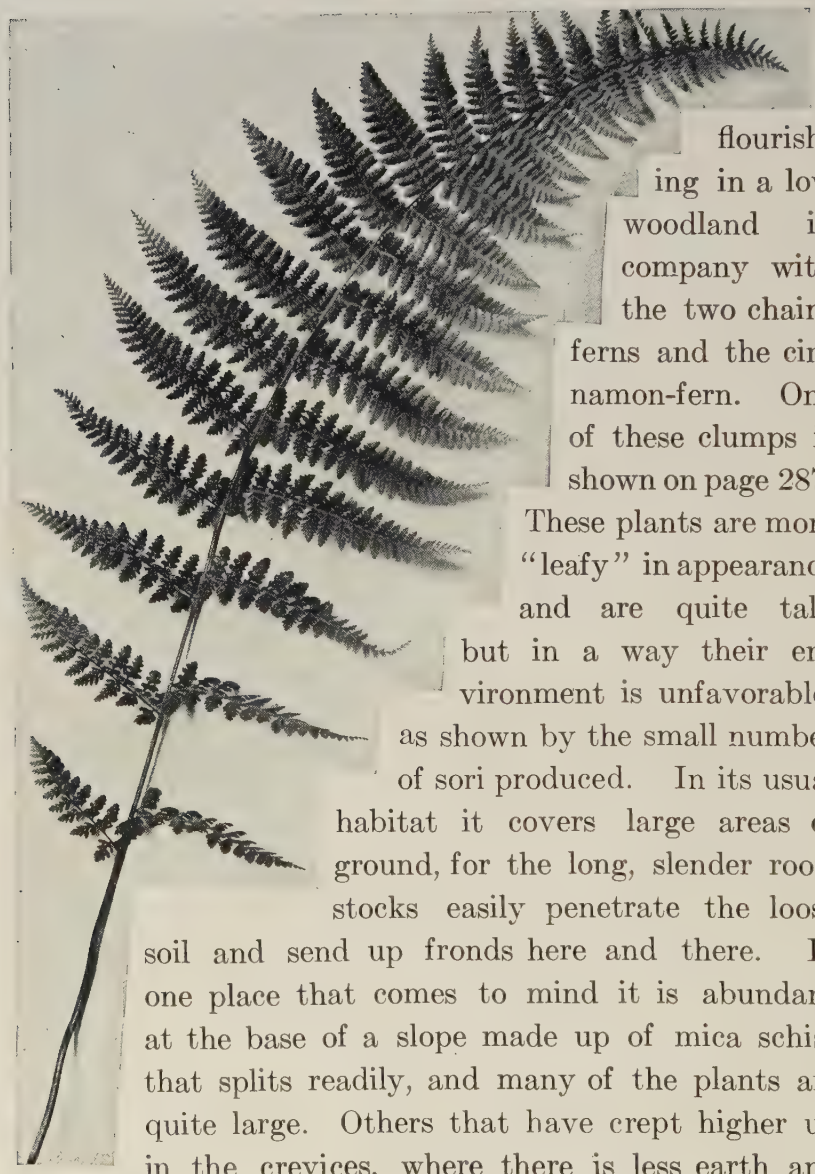
(B. *Dennstaedtia punctilobula.*)

Fronds one to three feet tall, ovate-lanceolate and acuminate, bipinnate minutely glandular and hairy. Pinnæ lanceolate, pointed. Pinnules pinnatifid with oblong, obtuse, cut-toothed lobes.

WE very often find the hay-scented fern on rocky banks in open woods and by the roadside, especially if the soil be rather sandy and poor. It is not usually found in wet situations, though we know of two or three dense clumps of it that are

Hay-scented Fern.

Page 287.



Hay-scented Fern.

flourishing in a low woodland in company with the two chain-ferns and the cinnamon-fern. One of these clumps is shown on page 287. These plants are more "leafy" in appearance and are quite tall, but in a way their environment is unfavorable, as shown by the small number of sori produced. In its usual habitat it covers large areas of ground, for the long, slender root-stocks easily penetrate the loose soil and send up fronds here and there. In one place that comes to mind it is abundant at the base of a slope made up of mica schist that splits readily, and many of the plants are quite large. Others that have crept higher up in the crevices, where there is less earth and moisture, are stunted and grow in tufts, in

imitation of the true rock-loving ferns that usually have this habit.

A peculiarity of the hay-scented fern that is not commonly known is the frequent occurrence of stipes that send forth rootstocks near their base about an inch or less above the parent rootstock. They can be seen as little knobs on the very young stalks, and they lengthen as they grow older. Cross-sections of the two rootstocks show the light and dark tissues arranged concentrically, but the little bit of stipe between them has the usual curved fibrovascular bundle. We have never seen one of these secondary rootstocks that was longer than an inch or two, even at the end of summer, and it may be that they do not develop further until the next year, or perhaps they die without sending up other fronds. It would be interesting for some one to clear up this point.

The sori of the Dicksonia are quite unlike those of our other ferns. The spore-cases are borne on a raised globular receptacle, and are enclosed in a cup-like indusium which is open at the top, and attached on one side to a recurved toothlet at the margin of the lobe. The sori are shown in the illustration on page 55.

The stalk and pinnæ of the hay-scented fern are covered with fine glandular hairs that seem to be in some way connected with the odor of the fern. The fragrant shield-fern and the sweet-scented variety of the New York fern are very glandular, while the ordinary form of the latter is nearly smooth and has but a slight odor. When the fronds of the hay-scented fern are fresh they possess but

little of the hay perfume, which is changed in character and intensified by drying. Plants that have grown in dry, sunny spots seem to have more of it than those in the shade. The oils to which so many plants owe their fragrance can generally be obtained by "distilling with steam," an operation familiar to the chemist. A considerable quantity of the partly dried fern was subjected to this process, and two or three drops of oil were obtained. It had a rather disagreeable odor, but when a drop or two of a solution of the oil in a large amount of ether was put on paper and the ether allowed to evaporate, a very pleasant reminder of "new-mown hay" resulted.

Fronds of the hay-scented fern are frequently forked at the tip, but as a rule it is quite constant in the cutting of its foliage. Second-growth fronds are apt to have rather broader divisions than those that come up earlier in the season, and they are usually sterile. A form with rather narrow fronds, the pinnæ unequal in length and with the teeth of the ultimate segments very deeply cut, so that each vein forms the midrib of a narrow tongue-like segment, has been named *D. pilosiuscula schizophylla.* So far no fertile fronds have been seen.

The hay-scented fern is found from Nova Scotia to Georgia, Alabama, and westward.

FERNS OF THE CURLY GRASS FAMILY

Curly Grass. 11.

Schizæa pusilla.

Fronds very slender; the sterile ones about an inch long, tortuous, flattened; fertile ones equally slender, erect, three or four inches tall, and bearing at the top about five pairs of crowded pinnæ, forming a two-ranked spike.

IN the New Jersey pine-barrens, and in Nova Scotia and Newfoundland, the curious little curly grass may be found by the fortunate botanist who happens to hit the right spot and has at the same time keen eyesight. It has never fallen to our lot to visit it in its home, but from all accounts it must be as difficult to catch sight of as to see the capsules on a clump of moss at one's feet.

The illustration gives some idea of the appearance of this fern. A fertile plant and a smaller sterile one are shown natural size. It looks less like a fern than any other species we have, and no one, on seeing it for the first time, would be apt to take it for anything but some diminutive sedge or curious grass with narrow, almost thread-like leaves. It is, indeed, not directly related to our common ferns,

Curly Grass. (Natural size.)

for the structure of the spore-cases compels the systematic botanist to place them in another family with the climbing-fern and other species that do not occur within our limits. On page 24 is a drawing of a spore-case of the climbing-fern, showing the jointed ring at the apex which is characteristic of this family. The four or five pairs of pinnæ are folded close together (see page 57) and bear the spore-cases on their inner surfaces where they will be protected.

The curly grass is to be looked for in pine-barren swamps along the coast in company with sedges, mosses, sundew, club-mosses, and similar bog-loving plants. It may yet be found in many stations not now known.

Hartford Fern; Climbing-fern. 12.

Lygodium palmatum.

Fronds one to four feet long, slender, twining, the short, rather distant branches two-forked, each fork bearing a roundish, palmately lobed pinnule. Fertile pinnules above, much contracted.

NO other fern has perhaps ever been the subject of a law prohibiting its destruction, but in 1869 Connecticut made it a misdemeanor to

pull or uproot the plant named after the capital of the state. It is a pity that such efforts to save rare and beautiful plants from destruction are not made oftener, so that future botanists might enjoy many that are rapidly becoming extinct. Every one should help along the cause of plant protection.

In the neighborhood of Baltimore the climbing-fern is practically extinct, for the small swamp, overgrown with sumac, alder, and other bushes, in which it grew has been nearly "cleaned out." Where it was once easy to find fronds three or even four feet long a few years ago, there was but one large enough to twine in 1902. The plants are not sold in the markets, but some one evidently admires them sufficiently to dig them up.

The name *Lygodium* is derived from a Greek word meaning "flexible," in reference to the twining stems of all the species. The illustration shows a plant twining around a stem of cat-brier. The fronds do not climb until they are about a foot long, the shorter ones spreading over the ground. The fertile pinnæ are at the upper part of the larger fronds. Instead of having two palmate pinnules as the sterile ones have, there are several smaller ones of the same general shape, as shown on page 58. Near the end of each of the little "fingers" are several overlapping scales that form the indusia. Each of these covers a single spore-case of the shape shown on page 24. Before winter the spores ripen and the fertile pinnæ turn brown, but the sterile ones remain green until late in the following spring.

We have seen how there may be forms intermediate

between the fertile and sterile fronds of the sensitive fern and other species in which the two kinds of frond are

Climbing-fern. (Reduced.)

quite unlike. Somewhat the same thing may be noticed in the climbing-fern. It not infrequently happens that one of

the two sterile pinnules may be changed into several of the ordinary fertile ones. Or we may see sterile pinnules with one or more of the lobes changed into a partly fertile pinnule. Again, a fertile pinnule may be more leaf-like than usual and bear sporangia only here and there, leaving some of the lobes sterile. Once in a while a frond is found with a few fertile pinnæ near the middle and with sterile ones above and below. Most of these forms have a curious appearance, and are apt to be mistaken for diseased or otherwise injured fronds by the casual observer.

The climbing-fern is found from New Hampshire to Florida. It is usually a coastal plant, but it occurs also in Tennessee and Kentucky.

THE FILMY FERN FAMILY

Filmy Fern.

Trichomanes radicans.

Fronds very delicate, four to eight inches long, oblong-lanceolate, bipinnatifid. Pinnæ triangular-ovate, the divisions toothed or again lobed. Rachis and upper part of stipe conspicuously winged.

N moist, dripping rocks from Kentucky to Alabama and Florida one may come across the delicate fronds of the filmy fern. It and a much smaller species from Alabama and Mississippi are our sole representatives of a large tropical family, the genus Trichomanes alone containing about one hundred species. Nearly all the members of the family grow on tree-trunks or on moist rocks, and they never reach as large a size as most other ferns. Even in their texture they are unlike ordinary ferns, for the main tissue of the frond is often but one layer of cells in thickness, except where the veins run. They are typical tropical plants, and it is a matter of surprise to learn that our species is not only hardy as far north as Kentucky, but that the fronds live several years. It is said that they do not begin to produce spores until the second or third year, and after that they bear sporangia for several years. At the edge of a lobe of the frond there is formed a cup- or funnel-shaped

hollow through the center of which a bristle, formed by the prolongation of a vein, runs. The spore-cases are borne on the lower part of this bristle. After the spores are shed they drop off, and the following season there are new ones produced at the base of the bristle, which has in the mean-

The Filmy Fern. (Slightly reduced.)

while elongated. This takes place for several successive years, so that finally the bristle may project quite a distance beyond the mouth of the funnel. This may be seen in the illustration on page 56.

The specimens shown in the illustration were collected in Kentucky.

FERNS OF THE FLOWERING FERN FAMILY

Royal Fern; Flowering Fern. 3.

Osmunda regalis.

Fronds two to six feet tall, bipinnate. Pinnules oblong-ovate or lance-oblong, finely serrulate, especially near the apex, otherwise entire, or crenately lobed near the rounded, oblique, or heart-shaped base. Fertile pinnæ in a panicle at the top of the frond.

IN open woods or wet thickets, or even in moist hillside pastures, the reddish green of the uncoiling fronds of the royal fern gives a pleasing touch of color early in the spring. It is seen at its best, however, in the shallow water along the edge of ponds and streams, where it often forms large clumps several feet high. The beautiful green of the mature fronds and their airy and graceful foliage are sure to win admiration, and it is said to be regarded as the handsomest British fern. But it must be remembered that fronds ten feet or more in length have been found in England, and they must be proportionately more stately than ours.

The pinnæ suggest somewhat a small locust leaf with

Royal Fern. × ½.

Page 299.

narrow leaflets, and they are not so very unlike in color and texture. No other fern that we have in any way resembles it, even the two related species of *Osmunda* being entirely unlike it except in their stalks. Each has in the stipe a single curved fibrovascular bundle with the edges rolled up in a peculiar manner, so that an *Osmunda* need never be taken for any other fern. Besides that, the base of the stipe is thin, and so spread out as to be almost like the stipules of flowering plants.

No one seems to know just why the name *Osmunda* was given to these ferns, though many suggestions have been made. Osmunder is a Saxon name for the god Thor, and both Eaton and Underwood give this as the probable derivation of the scientific name. Others refer to the story of Osmund the Waterman, who hid his wife and child in a clump of these ferns during an incursion of the Danes. Wordsworth speaks of

> "that tall fern,
> So stately, of the Queen Osmunda named.
> Plant lovelier in its own retired abode
> On Grasmere's beach, than naiad by the side
> Of Grecian brook."

The name "royal fern" is not inaptly chosen, and any one not a botanist would be justified in calling it the "flowering fern," for the clusters of large spore-cases at the summit of the frond are not unlike seed-vessels. The illustration on page 23 shows them enlarged only five and one-half "diameters," as the microscopist says. That is, they appear five and one-half times as large in every

direction as they really are. Compared with the illustration on page 52 we see that each spore-case of this species could enclose a whole sorus of the fragile bladder-fern.

Partly Fertile Pinna of Royal Fern. ×3½ Reprinted from the Plant World.

The fertile portion of the frond shows the greatest possible reduction of the leafy part, for nothing is left but the midribs and midveins upon which the spore-cases are borne. Sometimes we see partly fertile pinnæ, generally with a few spore-cases on one side of the contracted base. Or the tip may be partly contracted with a few scattered spore-cases along the edges. Other pinnules may be reduced to a narrow strip with a fringe of sporangia. These do not seem to be the result of an injury, though the analogous forms of the sensitive fern and other species are often so caused.

The royal fern is found from Newfoundland to Florida, and westward to Mississippi, Nebraska, and Saskatchewan.

Some botanists have quite recently come to the conclusion that the European species is distinct from our fern, but this view is by no means generally held. If it be correct, our species should be called *Osmunda spectabilis*.

The Interrupted Fern.

Page 302.

Interrupted Fern; Clayton's Fern. 2.

Osmunda Claytoniana.

Fronds two to four feet long, pinnate. Pinnæ oblong-lanceolate, with oblong, obtuse divisions. One to five pairs of fertile pinnæ at the middle of the frond.

ON stony banks by the roadside, in old pastures, and scattered through the woods from hilltop to hollow we can find the uncoiling croziers of the interrupted fern in the early spring. They are much like those of the cinnamon-fern, but are not so woolly, and there are other more subtle differences that the fern-student soon learns to recognize. Even the mature sterile fronds seem much alike to the beginner, though he may afterwards wonder why he ever had any trouble in distinguishing them. The interrupted fern is thinner in texture, and everything about it—the tips of fronds, pinnæ, and lobes—is more rounded than in the case of the cinnamon-fern. There is one sure way of telling them apart. The interrupted fern, unlike the cinnamon-fern, has no little woolly tufts on the under side where the pinnæ are attached to the stalk. Besides this there are slight differences in the stipes which are pointed out in the key.

The fertile fronds come up at the same time as the sterile ones, but they are more erect, and also considerably taller. A well-grown plant will have a circle of spreading sterile fronds surrounding a cluster of fertile ones. The change from one to the other is great enough to justify one in calling it the interrupted fern, though the name

was given for another reason. Near the middle of the frond there is a decided break where the fertile pinnæ are. These are of the true *Osmunda* type, being reduced to little more than midrib and midveins on which the spore-cases are borne. The latter are of a peculiar blackish-green color before the spores are shed. The number of fertile pinnæ depends on the size of the plant. Young plants may have but one pair of them, or only a single pinna with a sterile one to balance it, while it is not unusual to find large fronds with five, or occasionally more, pairs. The entire pinna is not necessarily fertile, and often there will be one or two ordinary sterile lobes near the base.

Interrupted Fern. (Reduced.)

A variety of the interrupted fern known as *O. Claytoniana dubia* has been known for a few years. "The two or three lower pairs of pinnæ are much like those of *O. Clay-*

Interrupted Fern.

toniana, except that they are rather more deeply cleft, and are oblong and obtuse, instead of oblong-lanceolate. The upper pinnæ, instead of being lanceolate and tapering, are oblanceolate to oblong-lanceolate, and instead of being cleft into oblong obtuse segments have, at their inner ends,

Cinnamon-fern.

Page 306.

oblong to oblong-ovate, obtuse pinnules, which are alternate and entirely separated by a distance equal to one-half to two-thirds their breadth. The upper-middle pinnules are also entirely separate, but in addition are greatly elongated, oblong-lanceolate, and cleft into oblong obtuse segments after the manner of the pinnæ in normal *O. Claytoniana*. In the fruiting specimens the fruit was borne as in *O. Claytoniana*, but the fertile and sterile pinnæ intergraded, as some of the pinnæ were wholly fertile, and others bore both fertile and sterile pinnules. Some of the pinnules even were in shape and texture like the sterile pinnules, but had sporangia at their edges."

Early in the fall the fronds of the interrupted fern turn yellow, and they are killed by the first frosts. The pinnæ drop off, leaving the bare stalks standing erect until they are beaten down by snow and wind. If torn away from the rachis when still green, the pinnæ leave a definite scar at the point of attachment.

The interrupted fern is found from Newfoundland to Minnesota and southward to North Carolina, Kentucky, and Missouri. The variety has been found only in Vermont.

Cinnamon-fern; Fiddle-heads; Brakes. 1.

Osmunda cinnamomea.

Fronds two to six feet long, pinnate. Pinnæ lanceolate, pinnatifid into broadly oblong, obtuse divisions. Fertile pinnæ on separate fronds.

EXT to the maidenhair, the cinnamon-fern is perhaps the best known of all our ferns, though it is apt to go under the name "brakes" like other

large, coarse ferns. It forms a prominent feature in wet meadows and in swamps, where it usually grows singly or in small clumps, but in low, wet woods which are not too dense to let in plenty of sunlight it covers large areas in company with skunk-cabbage, jack-in-the-pulpit, and other plants that can squeeze in between the taller ferns.

From the time the woolly "fiddle-heads" uncoil in the early spring until it is cut down by the killing frosts, the cinnamon-fern is one of the most attractive features of the woods (page 27).

The young fronds are provided with a thick woolly covering that falls off as they mature. But on the under side at the junctions of the pinnæ and rachis little tufts of these hairs remain as if to give us a sure means of identifying this species, for they are not found in any of our other ferns. Unfortunately

Cinnamon-fern. (Reduced.) *a*, fertile frond.

they do not show in the photograph of the tip of a sterile frond here given, for they are not much larger than a pin-head.

Cinnamon-fern.

In its fertile frond the cinnamon-fern goes a step beyond the other two Osmundas, for all the pinnæ are contracted and bear spore-cases, giving a more or less compact, cinnamon-colored cluster from which the fern gets its name

(p. 59). These come up a little before the sterile fronds, and are at first green, and very heavy with their load of spores. But they soon turn brown, beginning at the bottom, so that one may find empty sporangia and ripe and immature spores together. The spores, like those of the two related species, are green, and on account of their abundance of chlorophyll do not live many days after being shed. On the other hand, they germinate rapidly if they are planted on moist earth or sand, and are, for that reason, very satisfactory for laboratory work when we wish to study the young stages of the prothalli. The prothalli are unusually large, and the first two or three leaves are not just the same as those of most of our ferns. Instead of the one fan-shaped leaf (p. 30), each little stalk bears at its summit two that spread out horizontally in opposite directions.

When the early fronds are injured, the second growth is often of a peculiar character. The fertile fronds are only partially contracted, and they produce a much smaller number of spore-cases than usual, as we see from the portion of a pinna shown in the illustration. This form has been called *frondosa*.

Another form has been named *O. cinnamomea glandulosa* on account of the glandular hairs on the pinnæ, rachis, and upper part of the stipe. It can often be distinguished by the touch or by its slightly rusty appearance, and some fronds are so covered with the sticky glands that they adhere to the driers when in the press. More or less of the woolly covering of early summer is held until fall by the

glands. This form was found in Maryland in 1901, and in 1902 Mr. C. F. Saunders found it in New Jersey. It should be looked for in low woods along the Coastal Plain. It grows side by side with the ordinary smooth form.

Part of Pinna of the Form *frondosa*. ×5.
Reprinted from the Plant World.

Forms with the pinnæ more or less cut-toothed have been named *O. cinnamomea incisa*.

The cinnamon-fern is not commonly looked upon as a variable species, but by hunting around one may come across numerous peculiar forms of pinnæ. The lobes over-

lap, or are more or less distant, and they may be entire or crenate. Sometimes one of the basal lobes of a pinna is much elongated. A number of pinnæ are shown in the

Osmunda cinnamomea glandulosa. ×5½.

illustration on the next page. The broader ones were from plants growing in dense shade. They were thinner than usual, and the edges did not exhibit the usual slight tendency to curl over which is shown in the illustration on page 309. The largest pinna in the illustration was almost seven and one-quarter inches in length, but we have found others an inch longer.

When killed by frost the pinnæ drop off, leaving the stalks bare, just as those of the interrupted fern do. Even when green they are readily pulled off, leaving a more or

Sôme Pinnæ of the Cinnamon-fern. (Reduced.)

less definite scar. A number of our other ferns act in the same way.

Like the other Osmundas the cinnamon-fern has a short creeping rootstock, not very thick, that is covered with a

mat of roots and the undecayed bases of scores of old stalks. According to Clute there are often more than three hundred of these, not to mention many more that have decayed, so that one of these ferns may live as long as a forest-tree, for only a few fronds are produced annually.

The cinnamon-fern is found from Labrador to Minnesota, and south to the Gulf States and New Mexico. The form *frondosa*, of course, should occur anywhere within the same limits.

FERNS OF THE ADDER'S-TONGUE FAMILY

Moonwort. 49.

Botrychium Lunaria.

Plant very fleshy, two and one-half to twelve inches high. The leaf sessile or nearly so, near the middle of the stem, oblong, pinnate, with five to seventeen lunate or fan-shaped lobes that vary from crenate to entire, and are close together or distant.

THE family to which the moonwort and other related plants belong is, in many ways, unlike the true fern family, and the main points of difference were explained when the families of ferns were discussed (page 24). Most people on seeing a fruiting plant would be inclined to say that it was not a fern, for the sterile portion has not a very fern-like appearance, and the cluster of sporangia at the top only distantly reminds one of the Osmundas. The shape of this cluster has suggested the common name "grape-fern" that is applied to some of the species of *Botrychium*. For a long time botanists classed these ferns as Osmundas, for in both genera the spore-cases are large and are borne in much the same way. But there the resemblance ceases, and in almost all other respects they are quite unlike. Even

the resemblance between the spore-cases is only superficial, for, as we have explained on page 24, they are not produced in the same way.

The particular species known as "moonwort" is a native of Europe, and America. In the Eastern States it has been found as far south as Connecticut, and from there its range extends across central New York, and westward and northward. It is most readily known by the shape of the segments of the leaf, which are more or less like a crescent or half-moon in outline. The illustration, which is from a photograph of a European specimen, shows the shape of the segments, but does not give any idea of the fleshy nature of the stem and leaf which is so characteristic of most of the members of this family. Mr. George E. Davenport found that the buds can be relied upon as a means of distinguishing the different species of *Botrychium*. They are hidden in a cavity in the base of the stalk, and the leaf and fertile portion can be readily seen. In this species only the tip of the leaf is bent over the nearly straight fertile portion.

Moonwort.

The specific as well as the common name of this fern was given on account of the shape of the segments,

which have more or less the outline of a half-moon. It is not likely, from its rarity in this country, that any legends or superstitions ever sprang up in connection with it here; but in Europe, where it is much more abundant, it has a place in the folk-lore. A fancied resemblance, perhaps, to the shape of a horse's hoof led to the idea that treading on the plant would loosen the shoes of a newly shod steed. Superstitious folk are so ready to make mysteries of simple things that the occurrence of the plant in pastures and its unusual appearance no doubt had something to do with it. According to one writer, "Moonwort is an herb which they say will open locks and unshoe such horses as tread upon it." The poets, too, have not overlooked it. As one of them puts it:

Bud of *Botrychium Lunaria*. ×5½.

> "Horses that, feeding on the grassy hills,
> Tread upon moonwort with their hollow heels,
> Though lately shod, at night go barefoot home,
> Their master musing where their shoes be gone.
> O moonwort, tell us where thou hid'st the smith
> Hammer and pincers thou unshodst them with.
> Alas! what lock or iron engine is't
> That can thy subtile secret strength resist,
> Sith the best farrier cannot set a shoe
> So sure but thou so shortly canst undo."

And again:

> "There is an herb, some say, whose virtue's such
> It in the pasture only with a touch
> Unshoes the new-shod steed."

The other species of grape-fern do not share with the moonwort these superstitions.

The moonwort is found chiefly in fields and dry pastures.

For a number of years there has been known to a few botanists a fern that until recently has been regarded as a form of the moonwort. Quite recently, however, it has been described as a distinct species. Nearly all the specimens seen have been collected in the region of Syracuse, New York, but some have been found in Michigan, and similar plants are known from Montana. Apparently all the plants from central New York that have been regarded as the true moonwort are now to be named *Botrychium Onondagense*, as the new fern is called, on account of its occurrence in Onondaga County.

The new species is a slender fern with distant wedge-shaped segments. The leaf is "short-stalked, three-fourths to one and one-half inches long, and about half as wide; it has seven to nine broadly wedge-shaped segments which are spaced their own width or more, with one or more notches in the outer margin, or occasionally quite deeply incised." The fertile portion is "one-half to one inch long, mostly bipinnate, with a slender stalk." It is intermediate between *B. Lunaria* and *B. tenebrosum*. It can be told from the former by its distant wedge-shaped segments, and from the latter by its broader segments which are entire, or divided as stated above. The new fern is found in rich or sometimes in rocky or sandy soil, at the edges of woods or in thickets.

The genus to which this fern belongs is in such a state of turmoil at present that no two botanists seem to agree as to the exact limits of the species. One change follows another, perhaps in many cases without sufficient justification, and yet those who hold too strictly to the old nomenclature are as much in the wrong as the extremists in the other direction. It may be decided finally that this newest fern is only a variety of the moonwort, though that does not seem probable.

Little Grape-fern. 50.

Botrychium simplex.

Plant two to six inches high, slender, very variable. Leaf ovate, obovate, or oblong, entire, lobed, or pinnatifid, borne near the base of the stalk. Fertile portion a simple or somewhat compound spike.

T is small wonder that the little grape-fern is regarded as a rare species, in spite of its rather wide range from Quebec to Maryland and west to Wyoming, California, and Oregon. It must be a very inconspicuous object among the many plants that grow with it in moist woods and meadows. Perhaps a systematic search would show that it is more common than we think. Every worker in the field, which includes most botanists, for the "closet naturalist" is a nearly extinct species, knows how easy it is to overlook certain plants until his attention is called to them, after which they often cease to be rarities.

The stalks of our *Botrychia* are too much alike to be of much assistance in determining the species, but the

buds help us out again. Both the leaf and the fertile portion of the small grape-fern are erect in the bud. Besides, the position of the leaf near the base of the stalk of the mature plant is quite characteristic of this fern. The plant shown in the illustration represents only one of the many forms of the small grape-fern. It is not always, as its name denotes, a "simple" leaf, for fronds are sometimes found that are ternate, the three divisions being nearly equal. From these forms we can find all gradations down to a small ovate leaf hardly to be told from the adder's-tongue.

Little Grape-fern. (Natural size.)

Until quite recently, when a single plant was found near Washington, the most southerly station known for this species was at Ellicott City near Baltimore. The plants were discovered by Mr. J. B. Egerton some years ago. They have since been destroyed, for the field in which they grew has been turned into a garden.

Lance-leaved Grape-fern. 47.

Botrychium lanceolatum.

Plant three to twelve inches high, somewhat fleshy. Leafy sessile near the summit of the stalk, three-lobed or broadly triangular and bipinnatifid, the segments lanceolate, acute, entire or dentate. Midveins continuous, with forking veinlets.

THE lance-leaved grape-fern, another member of the troublesome group of small *Botrychia,* is found from Nova Scotia to New Jersey, Pennsylvania, Ohio, and other states to the west. It is found

in the most varied situations, but in general seems to prefer the moist rich soil in hollows in the woods. In such places it may be found in large numbers, though it is not a common fern, and one may search a long time without finding it. It is said that specimens a foot tall have been collected, but they do not average more than six or seven inches in length.

Bud of Lance-leaved Grape-fern. ×5.

Lance-leaved Grape-fern. (Natural size.)

It may be distinguished from the small grape-fern without much difficulty by the character of the buds, in which the fertile portion is bent over with the leaf reclined upon it. Besides, the leaf is near the summit of the stalk instead of below the middle, as it usually is in the latter species. It is not so easy to tell whether we have the lance-leaved or the matricary grape-fern, for the two are quite closely related, and have also about the same range, and are often found growing side by side. But here again we find the

buds to be of assistance. The differences are shown in the illustrations. In the lance-leaved species the midveins of the larger lobes are continuous, that is, they run to the tip without losing their identity, though lateral veinlets spring from them. In the matricary grape-fern the midveins fork repeatedly and are soon indistinguishable from the veinlets.

The rather large spore-cases begin to open about the middle of July, discharging myriads of sulphur-yellow spores.

Matricary Grape-fern. 46.

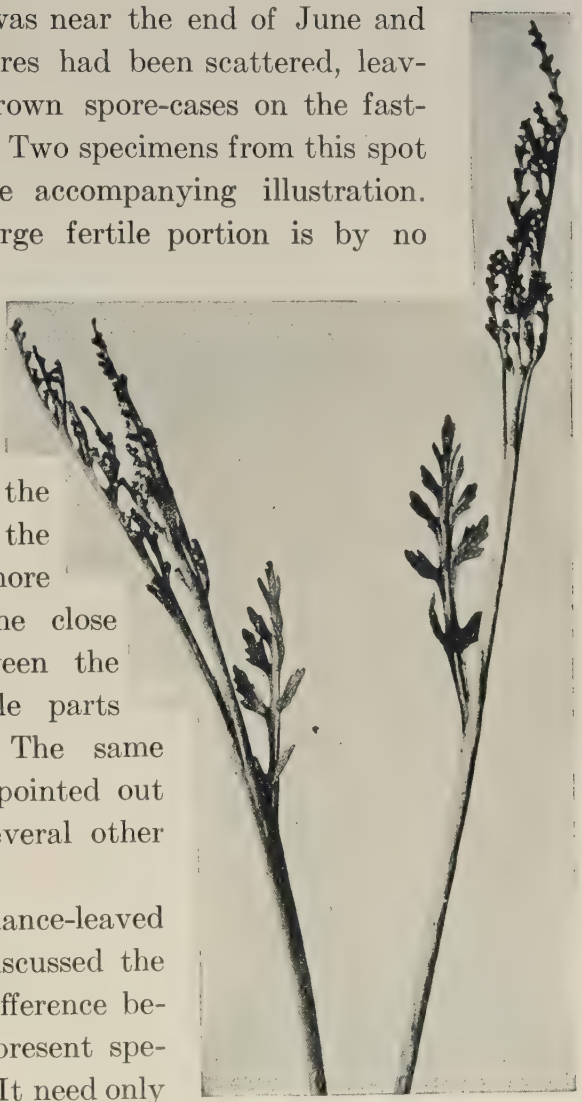
Botrychium matricariæfolium.

(B. *B. neglectum.*)

Plant two to twelve inches tall, often very fleshy. Leaf borne above the middle of the stem, short-stalked, ovate or oblong, once to twice pinnatifid, or rarely twice pinnate, with obtuse divisions and narrow-toothed segments. Midveins disappearing by continued branching.

E do not soon forget, even if we might wish to, the first glimpse of a new fern, or how a certain cardinal-bird looked as he came up almost within reach as we hid in a bush and whistled to him, or other occurrences of that sort. Once, while standing idly in a little woodland hollow near a stream, there seemed to bob up unexpectedly two plants of the matricary grape-fern, and a new species was added to the state flora. Cat-briers and poison-oak had no terrors then, and a search on hands and knees brought to light about twenty-five

more plants. It was near the end of June and nearly all the spores had been scattered, leaving the gaping, brown spore-cases on the fast-yellowing stalks. Two specimens from this spot are shown in the accompanying illustration. The relatively large fertile portion is by no means unusual. Sometimes solitary spore-cases or little clusters of them are seen on the edges of the lower lobes of the leaf, giving one more illustration of the close relationship between the fertile and sterile parts of the plant. The same thing has been pointed out in the case of several other species of ferns.



Matricary Grape-fern. (Natural size.)

When the lance-leaved grape-fern was discussed the main points of difference between it and the present species were given. It need only be added that in the matricary grape-fern the tips of both the leaf and the fertile portion are bent over in the bud.

The matricary grape-fern has about the same range as the preceding species, but it has been found a little farther south. Thirty or forty plants have been seen near Baltimore, and a single plant was found near Washington by a botanist of that city.

Bud of Matricary Grape-fern. ×5.

Eaton's Grape-fern. (Natural size.)

Page 325.

Eaton's Grape-fern. 48.

Botrychium tenebrosum.

Plant one to nine inches tall, slender, fleshy. Leaf above the middle of the stem, often just under the fertile part, short-stalked, entire, lobed, or usually with one to three pairs of distant, alternate, lunate, decurrent, entire segments; the apex emarginate, or with a triangular elongation. Fertile portion simple, or rarely with one or two short, somewhat dilated branches bearing spore-cases.

EATON'S grape-fern is an extremely variable plant that is found in "rich shady situations, usually among maples at the border of swamps." It often grows in sphagnum or among such deep layers of dead leaves that a third of the stem is underground. The plant has very little substance, and when dried is nearly transparent. It is quite small, the average height above ground being about three inches.

It has not been accepted as a valid species by all botanists, some regarding it as a depauperate form of the preceding fern, or even as a form of the little grape-fern. Mr. A. A. Eaton, who discovered it, lent us practically all his specimens, and it seems to us to be distinct from the other grape ferns. He says, according to Clute, that it "can always be distinguished from its allies by the notch in the tip of the sterile portion, and by the spores, which are nearly twice as large as those of *simplex*." The latter species has unusually large spores. The fertile portion is not bent over in the bud, and only the tip of the leaf is inclined. In this it resembles the moonwort.

The frond at the center of the illustration and the large one to the left bear a few spore-cases on the lower lobes. This is not an uncommon phenomenon in the species of *Botrychium*.

Eaton's grape-fern has been found from New Hampshire to Connecticut, in Long Island and central New York.

The illustration is from specimens in the herbarium of Mr. Alvah A. Eaton.

Ternate Grape-fern; Rattlesnake-fern. 5.

Botrychium obliquum and varieties.

Plant seven to eighteen inches tall, more or less fleshy. Leaf long-stalked from near the base of the stem, ternate with three nearly equal divisions, variously divided. Both portions of the hairy bud are bent over. Fertile part bi- to quadripinnate.

THE ternate grape-ferns are more or less of a bone of contention, for some botanists regard the different varieties as distinct species; but since so many intermediate forms are found connecting one with another, it seems best to keep them together. Several quite distinct varieties found within our limits have been named, the principal differences being in the cutting of the pinnæ.

B. obliquum.

(G. *B. ternatum obliquum;* G. *B. obliquum.*)

Bipinnate or somewhat tripinnatifid in larger forms, the segments obliquely ovate or oblong-lanceolate, with the end segment of each division somewhat elongated. Margins serrate or crenate.

For a long time this species was thought to be a variety of *B. ternatum*, a Japanese fern, but it is now generally conceded that this view is incorrect. It is a very variable fern, and many botanists regard some forms of it as distinct species. The typical form is found from New Brunswick to Florida, and also in Indiana and Minnesota.

The Ternate Grape-fern.
B. obliquum and var. *dissectum.*

Page 328.

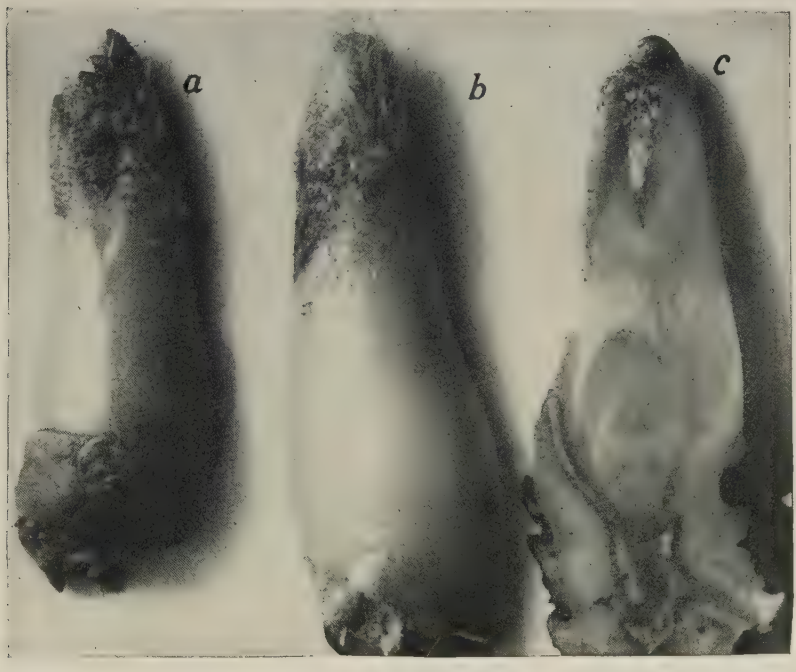
Late in the summer the plants start to grow, and in the course of a few weeks the leaf is fully expanded, and the sporangia at the top of their long stalks are rapidly turning yellow. They split open horizontally, the place at which the two halves separate being marked by a green line. The illustration on page 25 shows the spore-cases with some spores just escaping. From the millions of yellow spores one might expect the ternate grape-fern to be very abundant, but such is by no means the case. There is too much competition in the low, damp woods in which they are generally found, and it is not easy for sporelings to get a start in life. According to our own experience even the half-grown plants are much less numerous than the

Botrychium obliquum ×⅔

a, *Botrychium obliquum*; *b*, var. *intermedium*; *c*, var. *dissectum*; *d*, var. *Oneidense*.

Page 330.

larger ones, which seems to reverse the usual order of things. They have, apparently, no insect or other enemies, and no amount of crowding or shading seems to injure them when they are once established, but the young plants need



Buds of *B. obliquum dissectum*. ×5½. *a*, with hairs partly removed; *b*, in natural condition; *c*, longitudinal section.

more coddling than they are apt to receive from the lady-ferns and rich-weed, the May-apples and all the rest of the woodland company.

In the typical form, and also in variety *dissectum* a plant may have two or three fertile portions, their stalks arising about an inch apart on the common stalk, or more rarely opposite one another.

B. obliquum var. *dissectum.*

(G. *B. ternatum dissectum;* B. *B. dissectum.*)

Secondary pinnæ lanceolate from a broad base, and pinnate with deeply cut pinnules. The ultimate segments are narrow and often notched at the apex.

The dissected grape-fern is by far the most beautiful of all the varieties of the ternate grape-fern.

Dissected Grape-fern.

It has about the same range as *B. obliquum,* and is usually found in company with it. The illustration on

page 328 shows how they grow. There are two of each variety, with a fifth nearly hidden by the New York ferns at the right. Only a part of the fertile portion and its stalk can be seen. These were growing in the little woodland shown in the illustrations on pages 4 and 12, from which we can get some idea of the accompanying vegetation.

At this same place we once found a plant with two nearly equal leaves, but no fertile portion. The slightly smaller one probably represented the missing fertile branch.

The cutting of the fronds is not always like that shown at *c* in the illustration on page 330, for the segments are often much finer and closer together. It passes gradually over into *obliquum* through a succession of intermediate forms.

B. obliquum var. *intermedium.*

(G. *B. ternatum intermedium.*)

Leaf more divided than in *obliquum,* and the segments not so long and pointed. Usually larger and more fleshy than the other varieties.

This variety is much less common than the two preceding ones. It is more northerly in its range, being found only in New England and New York. We once collected it in pine woods in Maine. The soil was principally sand containing but little vegetable matter. The plants were quite different in general appearance from the preceding varieties, and, as Mr. B. D. Gilbert says, "it comes nearer to being an independent species than any of our other forms." The leaf of a plant collected in New York is shown at *b* on page 330.

B. obliquum var. *Oneidense.*

Pinnules of lower pinnæ one to one and a half inches long, sometimes deeply pinnatifid. Stalks of lower pinnæ each with three or four rounded lobes cut nearly to the midrib, and a terminal one. Lobes round-ended, generally entire, but very faintly toothed.

This variety is less divided than any of the others, and is one of the least common. It has been found

B. obliquum rutaceum. (Natural size.)

in central New York and also in the Catskills and near Washington. It should be looked for wherever the other varieties occur.

B. obliquum var. *rutaceum.*

(B. *B. matricariæ.*)

Small, with slender, fleshy stems. Leaf rather short-stalked, one or two inches long and wide, the three divisions similar, bipinnatifid or bipinnate. Ultimate segments small, one-eighth to one-fourth inch wide, rounded or somewhat obliquely ovate, the margins undulate or crenate.

This variety is also far from abundant, and it occurs only from central New York to northern

B. obliquum Habereri. ×½.

New England and Labrador. Like the other varieties it grows in low ground, preferably old meadows.

Two other varieties have recently been described by

Mr. B. D. Gilbert, who was also the first to call attention to variety *Oneidense.* The two new forms were discovered in central New York by Dr. J. V. Haberer, after whom one of them has been named *B. obliquum Habereri.*

B. obliquum elongatum. $\times\frac{1}{2}$.

The second of these two new ferns has been named variety *elongatum.*

These ferns wilt quite readily in dry weather, yet they

lose their moisture very slowly when we attempt to press them for the herbarium. The stems, especially, require a long time to dry, and we have found it advantageous to scratch them lengthwise with a pin so as to break the epidermis and hasten the process. The fronds of the other grape-ferns are usually dead before the approach of cold weather, but this species is evergreen, if we can so call plants that turn to a beautiful reddish-bronze color. If bent over and partly covered by fallen leaves, only the part exposed to the air is red, the rest remaining green. The red color persists until the fronds die early the following summer.

Rattlesnake-fern; Virginian Grape-fern. 51.

Botrychium Virginianum.

Plant four inches to over two feet high. Leaf sessile above the middle of the stalk, broadly triangular, thin, ternate. The short-stalked primary divisions once or twice pinnate, and then once or twice pinnatifid. The oblong lobes cut-toothed toward the apex. Fertile part twice or thrice pinnate.

HIS is by far the most handsome species of *Botrychium*, and it is not to be slighted in any company of beautiful ferns. It is seen at its best in low woods and shaded ravines where the soil is deep and moist. Plants that grow in the drier parts of the woods are usually stunted. There is a regular gradation in size from small plants that fruit when not more than three or four inches tall, up to the largest that may reach the height of two feet or more, with a leaf ten or twelve inches between the tips of the two lateral divisions. Before this was

recognized the small plants were thought to belong to a distinct species and were named *Botrychium gracile.*

Rattlesnake-fern.

A person not well acquainted with the grape-ferns might be apt to mistake this form for some other species, but here

Rattlesnake-fern. × ½.

Page 339.

again the work of Mr. Davenport helps us out of the difficulty. The bud is hairy and is enclosed in a cavity at one side of the base of the stalk (see page 28). In the other species the cavity is completely closed, but in this the edges of the opening are merely folded over to protect the bud inside. *B. gracile* is much thinner in texture than the other small grape-ferns.

"*B. gracile*." ×¾.

Large plants of the rattlesnake-fern are unlike any of our other large species, for the leaf is sessile near the middle of the stem, instead of growing on a long stalk arising near the ground. It also fruits earlier than the ternate grape-fern, so that there is no danger of mistaking one for the other. The plants begin to appear in April, and the spores are shed in June, after which the stalk above the leaf soon turns yellow and dies away. As shown on the preceding page, the fertile portion is somewhat compact when the spore-cases are young, but as they approach maturity the spaces between the branchlets lengthen and we have finally an elongated slender cluster with the branchlets nearly parallel to the stalk (see page 338). Plants have been found with two fertile portions, or more frequently with the stalks forked. At times it appears as if one of the branchlets had dropped down below the others and there developed into a miniature fertile stalk with branchlets and all complete.

The yellow spores are very numerous, but it is not always easy to find young plants, and the prothalli are seldom seen. They develop underground and appear like tiny tubers. One investigator, more successful than any other, obtained large numbers of them in a bed of sphagnum. If we look out for very small plants and dig them up carefully, we sometimes find the prothalli still attached to them as little, rounded, brownish masses.

A writer in the "Fern Bulletin" states that in parts of Kentucky the rattlesnake-fern is known as "sang sign," because it is believed that the tip of the frond always points towards a ginseng plant. The suggested explanation, which is probably the correct one, is that both these plants grow in similar situations, and it would often happen that the grape-fern would point in the direction of the other plant. In other parts of the South the fern is also called "indicator" for the same reason.

The Virginian grape-fern occurs nearly all over the United States and in parts of British America, as well as the West Indies, Japan, etc.

Adder's-tongue. 44.

Ophioglossum vulgatum.

Plant three to ten inches high. Leaf ovate to elliptic, or oblanceolate, usually with a long, narrow base. Fertile portion a long-stalked spike with the sporangia cohering in two rows.

HE adder's-tongue is entirely unlike a fern in its appearance, and it does not even resemble the grape-ferns that belong in the same family, except the simplest form of *B. simplex*. Besides occurring

in Europe it is found from Quebec and Ontario to Florida, and also in California, yet there are few localities where it is reported as common. It is often overlooked because it grows with other plants having similar leaves, but it is not hard to identify when one has become familiar with its appearance.

As a rule it grows in low meadows, but other places should be searched for it. Writers in the "Fern Bulletin" state that they have found it in dry pastures, or moist meadows, in dry woods, and elsewhere. We must add moist woods in company with May-apples, spring beauties, and similar plants.

Like the other members of the family the adder's-tongue has a short rootstock with a few fleshy roots devoid of fibers or root-hairs. Recent advances in botany have made it certain that many species of plants are more or less dependent on certain fungi, the *hyphæ* or thread-like, vegetative parts of which are attached to their roots. The fungus brings to the higher plant certain food materials, and is in turn benefited by its host. The root-hairs usually found on the roots of the higher plants disappear as the fungus threads become more numerous. In the orchids and adder's-tongue and other plants, the root-hairs have been entirely supplanted by the fungus growth or *mycorrhiza* (root-fungus), and even the underground prothalli are dependent upon them.

There would seem to be little opportunity for variation in such a simple plant, but two forms of the adder's-tongue have been described, which are regarded as distinct spe-

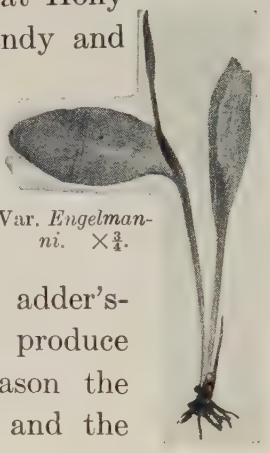
cies by some botanists. The arrangement of the veins is of importance in distinguishing them. In the typical form there are nine to eleven nearly parallel veins at the base. They are connected above by short oblique veinlets that form long, narrow meshes in the middle of the leaf and shorter hexagonal ones near the margin and apex. The longer meshes usually enclose one straight, free veinlet.

O. vulgatum. ×¾.

In the variety *Engelmanni* there are thirteen or more basal veins, the outer ones being curved. The transverse veinlets are oblique, forming large, oblong-hexagonal meshes enclosing numerous free or areolate veins. The leaf is elliptic or lanceolate-elliptic, with a minutely pointed tip. It has been found in Virginia and other southern states.

In the second variety, *arenarium*, we have a much smaller plant with a lanceolate leaf. There are but three to seven basal veins connected by veinlets, forming long, narrow meshes including a few faint free or areolate

veins. The marginal meshes are shorter and more irregular. A single colony of this form is known at Holly Beach, New Jersey. The soil is so sandy and sterile that many botanists are inclined to regard the plant as a depauperate or stunted form of the typical adder's-tongue.



Var. *Engelmanni*. ×¾.

According to certain observations published in the "Fern Bulletin," the adder's-tongue and some of the grape-ferns produce spores only on alternate years. One season the plants are nearly all sterile, and the next year fertile specimens are easily obtained. No one seems to have studied individual plants, and it would be of interest to watch a number of marked plants for several seasons in order to determine whether there is a resting period, and just how long it may be.

var. *arenarium*. ×¾.

The common name, adder's-tongue, of which *Ophioglossum* is a translation, comes from the appearance of the long fertile spike. In accordance with the ancient ideas about diseases and their cure, it was evident that this plant was intended by Nature as a specific for snake-bites. The same notion survives to-day in China and other less civilized lands in connection with many different plants and animals. If tigers are strong, their bones must be of use in weakening diseases. Ginseng roots often bear a slight resemblance to the

human body, which makes this plant so valuable for all ailments. It has not been so many generations since we took the steps that put us so far in advance of our oriental neighbors. Gerarde, the great herbalist, says that "the leaves of Adder's Tongue stamped in a stone mortar, and boiled in oyle olive unto the consumption of the juice, and until the herbs be dried and parched, and then strained, will yeelde most excellent greene oyle or rather a balsam for greene wounds comparable to oyle of St. John's-wort if it do not farre surpasse it."

FERN-PHOTOGRAPHY

NEARLY all the books about ferns and flowers that are written to appeal to the unscientific public fail to give directions for collecting and preserving herbarium specimens. We shall not depart from this unwritten rule, for it is only too easy to encourage the tendency to "make a collection," and there are no more ruthless destroyers of rare plants than amateur botanists, unless, perhaps, it be the professional collectors. In a leaflet issued by the Society for the Protection of Native Plants this has been brought out very clearly by George E. Davenport, the veteran fern-student. Some ferns, of course, can stand almost any amount of picking, but even then it should be made the rule, as suggested in the leaflet, "not to disturb the rootstock at all, and to gather fronds for specimens only when the crown of croziers is fully matured for the

next season's growth. By adhering to this simple rule, and with the aid of descriptive memoranda, the fern-student may safely prepare an herbarium with the satisfaction of knowing that the plants themselves will continue to live as long as the habitats remain in existence."

As Wordsworth says:

> "Move along these shades
> In gentleness of heart; with gentle hand
> Touch—for there is a spirit in the woods."

Photographing Outdoors.—But there is another way to preserve the ferns, and an interesting field for the amateur photographer, which lies in a different direction from the usual snap-shots of the baby and the family dog, is fern-photography. Without attempting to advertise any particular camera or brand of goods as the "only reliable," we will describe briefly the apparatus and methods made use of in preparing the illustrations for this book. The camera, which takes a picture five by seven inches, is a compact one with a long bellows and reversible back. For outdoor work we often slip a cheap "telephoto" lens over the usual one in order to increase the focal length and obtain better perspective in photographing groups of ferns. It is of advantage in photographing a single plant, for we can place the camera at a greater distance from it, and still get a good-sized picture with less chance of having some of the fronds out of focus. Isochromatic plates of moderate speed and sometimes a ray-filter are used. The image is made sharper and greater depth is obtained by a small diaphragm, and this increases the time of exposure so that a

tripod is necessary. In the woods we generally use stop No. 32. The greatest difficulty about this kind of work is the wind, which shakes the plants so that it is impossible to photograph them. There is nothing to do but wait until they are still, and we have stood by a plant as long as thirty minutes before a five- or ten-second exposure could be made. Focus upon the plants towards the center of the group, so that when the lens is stopped down more of the plants may be sharply outlined.

Indoor Photography. — Most of the ferns were photographed at home with a white background made of a piece of paper without water-marks, or a square of cheese-cloth. When the latter was used it was placed two or three feet behind the fronds so that the threads were out of focus. Small but typical fronds are best, for they need be reduced less, and the details are more distinct than if we choose large fronds. They can be attached to the paper by means of little bits of stiff paste put here and there. This gives a more life-like appearance than if the frond were fastened flat upon the paper. It is not hard to pick out the illustrations in this book which were made from herbarium specimens and the photographs of the fresh fronds. The small fronds of the purple cliff-brake were fastened to a pane of glass, with a white screen some distance behind, so as to avoid distracting shadows. The prothalli were arranged in the same way, but each one was put in a drop of water and straightened out with a pin or sharp pencil. The water was then removed by a bit of blotter. The glass should be placed nearly at right angles to the window

to avoid reflections that would show in the photograph. For indoor work we use stop No. 64, and give an exposure varying from thirty to seventy or more seconds according to the color of the fern and the light. In making an exposure it is best to shut the windows to avoid a draught that might shake the specimen. A side light seems to give the best results, and the use of a ray-filter was not found to be of any great benefit.

Photographing Sori.—The most interesting part of this work was photographing the sori. For this we should have fresh specimens in nearly every case, for the indusia are generally distorted and shrivelled in pressed specimens. Ordinarily in making enlargements, a small negative is made and from this is obtained a picture of the size required by projecting the image of the negative upon a sheet of sensitive paper in an enlarging-camera. There are certain disadvantages in connection with this, for we are obliged to use the enlarging-camera every time a print is desired, and there is a loss of sharpness and detail. By the method we have used a negative is obtained from which any number of contact prints can be made.

It is necessary to have a camera with a short-focus lens, and a long bellows. Our camera has a bellows extension of twenty-four inches, and the focal length of the regular lens is reduced greatly by means of a cheap "copying and enlarging" lens which slips on over it. By this arrangement an object can be enlarged about five and one-half diameters. The camera, fully extended, is placed upon a board thirty inches long, at one end of which are

two upright pieces with grooves into which a glass plate can be slipped. The fern pinna, or the portion of frond to be photographed, is pasted upon a small piece of smooth, white paper. This is best done by smearing a little paste upon a piece of glass, pressing the upper side of the pinna upon it for a moment and then upon the paper. Great care should be taken not to rub off the indusia. A new piece of paper is necessary for each bit of fern. This is then fastened upon the upright pane of glass and just opposite the lens of the camera by pasting the corners. To obtain the greatest magnification, the camera, with the bellows fully extended, is moved back and forth along the board until the fern is in focus. If we do not wish such a high power, the bellows is pushed in a little and the image focused as before. This requires great care, and when ferns with prominent sori are photographed, the sporangia and the edges of the lobes are not both in focus at the same time unless we increase the depth by using a very small diaphragm. The image also becomes much sharper when a small stop is used. The light should fall upon the surface of the pinna at quite an acute angle. We can tell the best direction by examining the specimen with a lens, turning it back and forth at the same time. It may seem a trivial matter, but in some cases a pinna held vertically will not give as good a photograph as when held horizontally, or when held with the tip pointing towards or away from the window. When the frond of *Asplenium ebeneum* shown on page 47 was photographed with the rachis horizontal, half of the sori were so shaded as to be nearly in-

visible; and if the light had fallen from the left instead of from the right, the indusia would have been quite inconspicuous.

Using a stop a little smaller than No. 64, and fairly rapid plates, the length of exposure averaged about forty-five seconds. Ordinary plates were used, for a ray-filter, or even isochromatic plates, reduced the contrasts which were wanted. A convenient size is $3\frac{1}{4} \times 4\frac{1}{4}$ inches. A rectangle of this size should be drawn in pencil upon the ground glass of the camera for convenience in centering and focusing. A very satisfactory "kit" to hold these small plates can be made by cutting a hole the size of the plate exactly in the middle of a five-by-seven-inch piece of heavy cardboard. Across each corner of the opening is pasted a narrow strip of heavy paper or of muslin to hold the plate in place.

Sun-prints.—If one wants simply to obtain prints showing the outlines of pinnæ or of small fronds, a very simple way is to make blue-prints. The fern is laid upon the sensitive side of the paper, and a plate of clean glass is put on top of that. To insure close contact between the fern and the paper, a folded newspaper is put behind the blue-print paper, and back of that a large book or stiff cardboard, and held firmly in place by spring-clips, rubber bands, or by the hands. For small fronds or pinnæ we can use an ordinary printing-frame. Print in direct sunlight to the proper tint and develop by washing in several changes of water. By a very long exposure to the sun a blue-print may be made to show the venation, though the specimen is apt to turn

yellow. To obviate this we can use one of the developing papers that print so quickly, even by artificial light. By exposure to daylight, not direct sunlight, for a few seconds, good prints that show the veins and even the fruit-dots can be made on "Velox" paper.

Paper Negatives. — Prints made in the way stated above are negatives, that is, we have a light image with still lighter veins upon a dark ground, and they can be used to obtain positive prints with the veins and stems dark as in the original. The picture is to be printed exactly as if one were using an ordinary film or glass negative, but long exposures are necessary because the thick paper retards so much of the light. Dr. R. H. True, who has made prints from similar negatives, suggests the use of a little coal-oil to make the paper more transparent. A solution of paraffin in benzene ("benzol") would probably answer the same purpose and also be cleaner to handle.

A Paper Negative

On page 355 is a print from the negative here shown.

When a frond is too thick to show the veins satisfac-

torily it may be bleached by soaking it in Javelle water until perfectly white. Then place it in dilute acid (vinegar and water will answer) for a few minutes, soak in a large dish of water for half an hour, and dry between blotters. Sometimes the bleached ferns can be used as they are, but by staining better prints can be made. Common red ink diluted with water can be used as the stain. Javelle water suitable for our purpose is made by dissolving sodium carbonate (washing-soda or sal-soda) in water and shaking up with it an equal weight of "chloride of lime." When it has settled the clear liquid may be used. The strength needed is best determined by experiment. It should not act too quickly or it will destroy the specimens.

Line Drawings are easily made from blue-prints. It is only necessary to go over the outline with waterproof drawing-ink and then to destroy the blue color of the paper with something that will not attack the ink. After the ink is thoroughly dry the prints are soaked in a very dilute solution of common soda (sal-soda) in water. They should then be rinsed with water, immersed a few moments in quite dilute sulphuric or hydrochloric acid to remove the yellow stain, then thoroughly washed in water and dried.

It should be remembered that these acids and Javelle water are apt to have a bad effect upon the skin, unless carefully washed off.

GLOSSARY

(In many cases definitions are not given, but instead reference is made to the pages on which the particular word or subject is explained, or on which there is a picture illustrating the term in question. The Arabic numerals refer to the text, the Italics to the illustrations.)

Acuminate. Gradually tapering at the end. *131, 160.*

Antheridium. 29.

Antherozoid. 29.

Apogamy. 34.

Apospory. 34, *35.*

Archegonium. 29.

Areolate. With the veins forming meshes.

Areole. A mesh in a network of veins.

Articulate. Jointed.

Auricle. An ear-shaped lobe at the base of a pinna or of a simple frond. *51, 180.*

Auriculate. Having auricles at the base. *51, 180.*

Bipinnate. Twice pinnate. *210.*

Bipinnatifid. Twice pinnatifid, or pinnate with pinnatifid pinnæ. *226, 267.*

Chlorophyll. The green coloring matter of plants.

Cordate. Heart-shaped.

Crenate. With much rounded teeth.

Crenulate. Diminutive of crenate.

Croziers. 25.

Areolate Veins.

Cryptogam. A flowerless plant. 18.

Decurrent. Running down the stem below the point of attachment.

Deltoid. Broadly triangular like the Greek letter *delta. 190, 264.*

Dentate. With outwardly projecting teeth.

Elliptic. Shaped like an ellipse; oval.

Emarginate. Having a notch at the end.

Evanescent. Soon withering away.

Fertile. Bearing spores.

Fibrovascular bundles. 2.

Forked. Divided into nearly equal branches. *15.*

Form. 11.

Free. Said of veins whose ends do not unite to form meshes. *356.*

Fronds. The leaves of ferns.
Fruit-dot. A sorus. *19.*
Genus. 9.
Gland. A cell, usually a hair, that yields a secretion.
Lobe. A division or segment.
Lunate. Shaped like a half-moon or crescent. *316.*
Midrib. The central leaf of a leaf.
Mycorrhiza. 342.

Forked Veins.

Glandular. Having glands.
Habit. The general appearance of a plant.
Hybrid. 33.
Imbricated. Overlapping. *58.*
Incised. Cut into sharp lobes. *217.*
Indusium. The thin membrane covering a fruit-dot. 19.
Laciniate. Cut into narrow, pointed lobes.
Lanceolate. Much longer than broad, and tapering from near the middle to the tip. *246, 256.*
Linear. Long and narrow with parallel margins. *137, 143.*
Oblanceolate. Lanceolate with the broadest part near the apex.
Oblong. Much longer than broad, and with nearly parallel sides. *229.*
Obovate. Inverted ovate.
Oöspore. 29.
Ovate. Egg-shaped with the larger end downwards. *231.*
Palmate. Diverging like fingers. *58*
Peltate. Shield-shaped and attached by the lower surface. *51.*
Pinna. A primary division of a pinnate frond.

Pinnate. Divided into leaflets along a common stalk. *137, 160.*

Pinnatifid. Cut half-way or more to the midrib. *80.*

Pinnule. A secondary pinna. One of the leaflets of a pinnate pinna.

Prothallus. 29, *30.*

Pubescence. A hairy covering.

Pubescent. Hairy.

Rachis. 67.

Recurved. Curved backward. *200, 208.*

Reflexed. Abruptly bent or turned backward. *45.*

Reniform. Kidney-shaped. *Indusia, page 51.*

Reticulate. Net-veined; see **Areolate.**

Rhizoid. 29.

Rhizome. 35.

Rhomboid. Obliquely four-sided. *92.*

Root-hair. A rhizoid. 29.

Rootstock. A rhizome. 35.

Segment. One of the parts of a divided leaf or pinna.

Serrate. Having teeth pointing forward. *19, 148.*

Serrulate. Finely serrate.

Sessile. Not stalked.

Simple. Not lobed or forked.

Sinuate. With strongly wavy margins. *264.*

Sinus. The cleft between two lobes.

Sorus. A fruit-dot. *19.*

Species. 9.

Spinulose. With bristly tips. 217.

Sporangium. A spore-case. 19, *23.*

Spore. 18, *29.*

Spore-case. 19, *20, 23.*

Stalk. 67.

Stipe. 68.

Ternate. Divided into three main segments. *94, 195.*

Tripinnate. Thrice pinnate. *119, 219.*

Tripinnatifid. Thrice pinnatifid, or bipinnate with pinnatifid pinnules. *215.*

Truncate. Ending abruptly as if cut across the end.

Variety. 11.

Venation. The arrangement of the veins.

Wing. A thin expansion or margin running along a stem.

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